BUILDING PROFESSIONAL IDENTITY AS COMPUTER SCIENCE TEACHERS: SUPPORTING HIGH SCHOOL COMPUTER SCIENCE TEACHERS THROUGH REFLECTION AND COMMUNITY BUILDING

A Dissertation
Presented to
The Academic Faculty

by

Lijun Ni

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy in Human-Centered Computing

School of Interactive Computing
Georgia Institute of Technology
December 2011

BUILDING PROFESSIONAL IDENTITY AS COMPUTER SCIENCE TEACHERS: SUPPORTING HIGH SCHOOL COMPUTER SCIENCE TEACHERS THROUGH REFLECTION AND COMMUNITY BUILDING

Approved by:

Dr. Mark Guzdial, Advisor
School of Interactive Computing
Georgia Institute of Technology

Barbara J. Ericson
College of Computing
Georgia Institute of Technology

Dr. Amy Bruckman
School of Interactive Computing
Georgia Institute of Technology

Dr. Joanna Goode
Education Studies Department
University of Oregon

Dr. Janet L. Kolodner
School of Interactive Computing
Georgia Institute of Technology

Date Approved: November 1, 2011

ACKNOWLEDGEMENTS

First, I'd like to begin by thanking my advisor, Mark Guzdial, who has been a great mentor and friend for over five years. He has inspired me with his passion in research and his enthusiasm in life. He has led me into the fields of learning sciences & technologies and computing education research, which were both new lands for me a few years ago. All along the way, he has provided wisdoms and knowledge for my success as well as patience and encouragement to many failures I went through. He has showed me how to be a good researcher and what a best mentor looks like.

My committee members, Amy Bruckman, Barb Ericson, Joanna Goode and Janet Kolodner have provided invaluable feedback about my work, and they have inspired me to think about my work from different perspectives. All of these four mentors have served as role models for me, who present identities as a good research, a great mom and a wonderful woman all together. I also thank the faculty and staffs at College of Computing, who have offered insights and support for me, especially Beki Grinter, Beth Mynatt, John Stasko, Maureen Biggers, Monica Ross and David White.

I also extend my thanks to colleagues in the computing education research community, who have shaped my ideas greatly. In particular, I deeply value the guidance of Josh Tenenberg, Sally Fincher and Steve Cooper along the journey of developing the Disciplinary Commons for Computing Educators (DCCE). I also owe gratitude to my collaborators and computing teachers in DCCE, especially Briana Morrison and Ria Galanos in the past three years.

I am grateful to my friends and fellow students at Georgia Tech for their intellectual support and friendship. In particular, I thank Marshini Chetty, Tammy Clegg, Jill Dimond, Christina Gardner, Mike Hewner, Hyungsin Kim, Brian Landry, Zhicheng Liu, Kurt Luther, Jeff Rick, Yan Xu, Sarita Yardi, and many more. Especially, I'm indebted to Brian Dorn and Allison Elliott Tew for her camaraderie and support with my research, who have tolerated my poor English and helped with their patience and insights.

I am thankful for the National Science Foundation's research funding that supported much of my years at Georgia Tech. Specially, NSF grants BPC # 0634629 and CPATH #0829601 made the research presented here possible.

Finally, I'd like to thank my family and friends in China, for their understanding and encouragement throughout the process. Also to my husband, Jia, who has always been supportive for me to pursue my own dream. Thanks to my son, Roger, who gives me the opportunity to face different challenges and enjoy the amazing life as a mom.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

Computing education requires qualified computing teachers. The reality is that too few high schools in the U.S. have computing/computer science teachers with formal computer science (CS) training, and many schools do not have CS teacher at all. Moreover, teacher retention rate is often low. Beginning teacher attrition rate is particularly high in secondary education. Therefore, in addition to the need for preparing new CS teachers, we also need to support those teachers we have recruited and trained to become better teachers and continue to teach CS. Teacher education literature, especially teacher identity theory, suggests that a strong sense of teacher identity is a major indicator or feature of committed, qualified teachers. However, under the current educational system in the U.S., it could be challenging to establish teacher identity for high school (HS) CS teachers, e.g., due to a lack of teacher certification for CS.

This thesis work centers upon understanding the sense of identity HS CS teachers hold and exploring ways of supporting their identity development through a professional development program: the Disciplinary Commons for Computing Educators (DCCE). DCCE has a major focus on promoting reflection on teaching practice and community building. With scaffolded activities such as course portfolio creation, peer review and peer observation among a group of HS CS teachers, it offers opportunities for CS teachers to explicitly reflect on and narrate their teaching, which is a central process of identity building through their participation within the community.

In this thesis research, I explore the development of CS teacher identity through professional development programs. I first conducted an interview study with local HS CS teachers to understand their sense of identity and factors influencing their identity

formation. I designed and enacted the professional program (DCCE) and conducted case studies with DCCE participants to understand how their participation in DCCE supported their identity development as a CS teacher.

Overall, I found that these CS teachers held different teacher identities with varied features related to their motivation and commitment in teaching CS. I identified four concrete factors that contributed to these teachers' sense of professional identity as a CS teacher. I addressed some of these issues for CS teachers' identity development (especially the issue of lacking community) through offering professional development opportunities with a major focus on teacher reflection and community building. Results from this work indicate a potential model of supporting CS identity development, mapping the characteristics of the professional development program with particular facets of CS teacher identity.

This work offers further understanding of the unique challenges that current CS teachers are facing in their CS teaching, as well as the challenges of preparing and supporting CS teachers. My findings also suggest guidelines for teacher education and professional development program design and implementation for building committed, qualified CS teachers in ways that promote the development of CS teacher identity.

CHAPTER I INTRODUCTION AND MOTIVATION

Computer science education (more broadly called computing education) is critical in both secondary and post-secondary systems. In a variety of ways, computer science education can contribute to the intellectual development of students, the innovation potential of other scientific disciplines, as well as the economic well being of countries (Ericson, et al., 2008; Shackelford, 2005). K-12 schools have a unique opportunity and responsibility to address the need of improving the level of public understanding of computer science as an academic and professional field, as well as to help address the shortage of computer specialists needed by our society.

However, computer science (CS) is a relatively young discipline in K-12 education. CS educators and researchers are concerned that K-12 students lack the opportunity to become familiar with and well prepared to pursue an expertise in this area at the college level (Margolis, Estrella, Goode, Holme, & Nao, 2008). In 2005, the Computer Science Teachers Association (CSTA) was formed by the Association for Computing Machinery (ACM) in response to growing concerns about the state of computer science in K-12 schools, such as courses offered and topics covered, gender, equity and enrollments in K-12 CS education, teacher certification and professional development. Among a variety of challenges we are facing in K-12 CS education, teacher related issues are one of the central aspects, which involves the recruitment of CS teachers, pre-service CS teacher preparation and in-service teachers' professional development.

To achieve quality CS education, we need qualified CS teachers. The reality is: Too few high schools in the U.S. have computing/CS teachers with formal CS training and many schools do not have CS teacher at all. For example, for the Advanced Placement (AP) CS course, which is the only HS CS course that currently carries college preparatory credit, we have a very small number of schools that are approved by the College Board to use the AP CS A designation on their transcripts[1].

Table 1: Number of Schools Offering AP Courses in 2009-2010 and 2010-2011

(The original data come from the AP CS Audit website[1].)

Subject	**Nationally**		**Georgia**	
	2009-2010	**2010-2011**	**2009-2010**	**2010-2011**
Biology	8238	8277	288	279
Calculus AB	11206	11173	388	379
Chemistry	6513	6613	237	223
Statistics	5217	5363	224	222
Computer Science A	2019	1820	72	57

The number of schools offering AP CS also indicates the rough number of AP CS teachers teaching that course (usually with one AP CS teacher for each school). In 2004, approximately only 44 Georgia schools offered AP CS A. With the big effort of training CS teachers led by the Institute of Computing Education (ICE)[2] since 2004, we have seen a significant increase in the number of AP CS teachers in Georgia. In 2009, we have 72 schools offering AP CS, with 68% increase in the number of AP CS teachers in Georgia.

---

[1] AP CS Audit: https://apcourseaudit.epiconline.org/ledger/search.php.
[2] ICE website: http://coweb.cc.gatech.edu/ice-gt.

Although we see efforts like Georgia Computes![3] and Into the Loop[4] working hard to increase the number of CS teachers and have made great progress, the number of AP CS teachers nationally is still relatively very small, compared with those of other STEM subjects, e.g., calculus, biology and chemistry (see Table 1).

When looking at the challenges we are facing in preparing qualified CS teachers, in addition to the great need for increasing the number of CS teachers, I see the need to support those teachers to grow and stay as committed, qualified CS teachers as teacher retention is often a big issue in secondary education (NCTAF, 2002, 2003). This thesis work explores ways of supporting CS teachers through studying their teacher identity. Here, *teacher (professional) identity* is defined as *being recognized as a certain kind of teacher by self or others* (Andrew, 1997; Gee, 2001; Ottensen, 2007). More discussion about related concepts such as identity, teacher identity and CS teacher identity can be found in Chapter 2. In the next section (Section 1.1), I will first introduce my motivation for studying teacher identity including the issue of teacher commitment and retention and the role of teacher identity in influencing different aspects of teachers and teaching. Then, I will discuss some unique challenges of developing teacher identity for CS teachers and thereby the need of supporting their identity development. The rest of this chapter will introduce the overall research agenda (Section 1.2) and provide an overview of the rest of this document (Section 1.3).

---

[3] GaComputes! project: www.gacomputes.org.
[4] Into the Loop project: http://intotheloop.gseis.ucla.edu/contact_us.html.

1.1 Challenges of Preparing and Supporting CS Teachers

1.1.1 Teacher identity matters

The motivation to explore teacher identity emerged from the need to gain understanding of the extent to which teachers are committed to reconstructing their existing identities as they face the challenges of changes in school reforms (Cardelle-Elawar, Irwin, Lizarraga, & Lusia, 2007; Luehmann, 2007). The literature on teacher identity suggests that identity reflects a subtle dimension of the complex and ongoing process through which teachers get to know themselves, their students, and the subject matter they teach (Cardelle-Elawar, Irwin, Lizarraga, et al., 2007). It reveals a set of values, beliefs and goals that shape how teachers make sense of their own teaching experiences. Therefore, teacher identity strongly determines the way teachers teach, the way they develop as teachers, and their abilities and willingness to cope with educational change and to implement innovations in their own teaching practice (Beauchamp & Thomas, 2009; Beijaard, Meijer, & Verloop, 2004). For example, Margolis et al (2009) find that teachers who do not value CS as a priority for students to learn would not be willing to invest energy to recruit students into CS courses.

Especially, recent teacher identity research suggests that teacher identity is central to sustaining motivation, efficacy, job satisfaction and commitment, and these attributes are crucial in determining whether teachers leave or stay in the profession (Chan, Lau, Nie, Lim, & Hogan, 2008; Day, Kington, Stobart, & Sammons, 2006). For example, Hong (Hong, 2010) found that teachers who dropped out indicated more negative aspects of their teacher identity. In summary, identity is seen as a key factor in becoming and being an effective teacher. The next section discusses two particular challenges of teacher

education that lead me into the issue of professional identity for CS teachers: teacher retention and teacher change.

1.1.2 The issue of teacher retention

Preparing and supporting K-12 CS teachers is a critical task in order to achieve quality CS education. Furthermore, I argue that we need to balance our efforts to recruit and prepare high quality CS teachers with ongoing supports and strategies for sustaining qualified CS teachers. This argument is driven by the issue of low teacher retention rate in general (NCTAF, 2002, 2003). As the National Commission on Teaching and America's Future reports (NCTAF, 2003), "our inability to support high-quality teaching in many of our schools is driven not by too few teachers entering the profession, but by too many leaving it, that is, by a staggering teacher turnover and attrition rate." Teacher turnover is significantly high, and especially beginning teacher attrition is a serious problem (Ingersoll, 2002). Based on an analysis from the National Center for Education Statistics for 1999-2000 school year, it is estimated that almost a third of America's teachers leave the teaching profession sometime during the first three years of teaching, and almost half leave after five years (Ingersoll, 2001). The attrition rate for those who enter through some "alternative" pathways (other than standard certification) can be as high as 60% (Darling-Hammond, Berry, & Thoreson, 2001). Moreover, attrition rates for special education, mathematics and science teachers are more than twice the rates for social studies teachers (Ingersoll, 2001).

Therefore, we are facing a big challenge of sustaining our teachers overall. Considering the current situation of CS education, we are working hard on preparing more CS teachers, which means we are going to have many beginning CS teachers in the

near future. For example, the CISE (Computer & Information Science & Engineering) Directorate of the National Science Foundation (NSF) proposes to develop an effective high school curriculum that will be taught by 10,000 well-prepared teachers in 10,000 high schools by 2015 (CS/10K Project). Here, in addition to developing an innovative curriculum, the greatest challenge will be scaling the teacher preparation opportunities and support to reach 10,000 computing teachers by 2015 (Cuny, 2010). Looking forward to 2015, we hope to have 10,000 well prepared teachers. As currently we only have about 2000 CS teachers, there will be 8000 relatively new CS teachers teaching in those schools. If the typical teacher turnover rate holds true for these new CS teachers, we are going to lose around half of them by 2020. Therefore, the key question for us is: how do we sustain the good teachers we have recruited and trained?

High teacher turnover can be a serious problem. First, the costs of replacing those leaving teachers every year is enormous. For example, a study in Texas revealed that the state's annual turnover rate of 15.5% of all teachers, which included a 40% rate for teachers in their first three years, cost a "conservative" $329 million a year. If the organizational costs of termination, substitutes, learning curve loss, and new training are included, then the price tag could go as high as $2.1 billion (NCTAF, 2002). High turnover also severely undermines our ability to build and sustain professional teaching communities in our schools. It also undercuts our ability to implement school reforms, and build our capacity to sustain school improvements. The most serious consequence is that high turnover diminishes teaching quality and student achievement.

Many studies have sought to understand teacher turnover. Four major factors are identified that are especially prominent influences on whether and when teachers leave

specific schools or the profession entirely: salaries, working conditions, teacher preparation and mentoring support for the early years of teaching (NCTAF, 2002). The first two factors often have deep roots. The latter two factors are more often the arena of teacher educators. The theory of teacher identity offers a particular conceptual lens for us to understand the issue of commitment and retention. Teachers' sense of commitment is tightly linked with their sense of identity, or sometime is seen as one aspect of teacher identity (Beauchamp & Thomas, 2009; Day, et al., 2006). Becoming a teacher who values, is able to and willing to engage and stay in their teaching profession requires developing a professional identity as a subject teacher (e.g., a science teacher, or a CS teacher). Therefore, preparing and supporting (CS) teachers need to take in consideration of the ongoing process of professional identity building.

1.1.3 Teacher identity and curriculum innovations

As introduced earlier, teacher educators find that teacher identity significantly influences teachers' attitude to changes caused by educational reforms. My own studies on how CS teachers change also reveal that teachers' attitudes significantly influence their decisions and actual adoption process of curriculum innovations (Ni, 2009; Ni, Mcklin, & Guzdial, 2010). Many of these attitudes are relevant to their own sense of teacher identity.

As we know, teachers are the "cornerstone" in implementing educational innovations. While studying factors that influence CS teachers' adoption of curriculum innovations, my colleagues and I have found that teachers' attitudes and beliefs about themselves, students, curriculum and school context are major factors influencing their adoption decision (Ni, 2009; Ni, et al., 2010). Quality workshops on those innovations do

not guarantee actual adoptions. When facing changes and innovations, teachers bring their own beliefs, and they will question how the new innovation might match or not match their current beliefs about themselves, students, curriculum and institutional context. For example, some teachers may question whether a new curriculum is a *real* CS course, and they may decide not to adopt it if the new course doesn't fit with their definition of CS. Some other teachers may also refuse a new curriculum if they do not see it as the kind of course their students are able to learn, e.g., when the new curriculum is developed by a stronger university. Similarly, some others might also take their own self-efficacy into consideration while making adoption decisions. What's implied in CS teachers' adoption decision process actually involves their reflection on essential questions of who they are, what they are teaching, what they are attempting to achieve, what they are capable of, who are their students, and what are the constraints from their institutions.

Although the previous work on CS teachers' adoption of curriculum innovations does not explicitly focus on their sense of identity, it offers examples for us to understand the role of teacher identity can play in curriculum change. As stated earlier, a sense of professional identity influences many aspects of teachers' teaching, which becomes a key factor in becoming and being an effective teacher.

1.1.4 Teacher education for developing teacher identity

Seeing the importance of teacher identity in teacher development, it is natural for us to ask: how can teacher education programs address the issue of teacher identity?

Though we have learned much about the essential elements of successful teacher preparation in general (Borko, 2004; Putnam & Borko, 1996), we are aware of the

complexity involved in preparing and further supporting teachers, regardless of the subject matter of specialization. In addition to learning a complex of set of skills of teaching and disciplinary content, novice teachers need to learn to deal with a series of challenges in their teaching practices. For example, beginning teachers need to posit themselves within a larger political and cultural community of practice. They need to define the roles they expect to play, determine the alignment or misalignment of their teaching practice with various power sources, policies and existing cultures; they also need to connect, integrate and reconcile various sources of theory and experiences of practice, and develop confidence and commitment in themselves as effective teachers (Luehmann, 2007). What is implied in this learning process is a core need and ongoing process of developing a (new) professional identity (Beijaard, et al., 2004; Luehmann, 2007). As Alsup (Alsup, 2006) concluded in her book, *Teacher Identity Discourses*, "Beginning teachers also need a teacher education that provides them with opportunities to develop satisfying professional identities, so that they can live and work in challenging institutional environments."

I argue that becoming a CS teacher who values, is able to, and willing to engage in CS education also involves much more than acquiring a new set of knowledge and skills related to the subject and pedagogy. This process could be better understood and supported as we think of it as developing a professional identity. More than what a teacher knows and believes about her practice, teachers' (professional) identity includes her professional philosophy, passions, commitments, ways of acting and interacting, values and morals, etc. These various ways a teacher engages and participates in her

practice can be accessed and operationalized through instances in which she is recognized as a certain kind of teacher by self and others—teacher identity (Sfard & Prusak, 2005).

This thesis work does not directly study the relationship between teacher commitment and identity, identity and reform/change, or other relations between identity and other aspects of teachers. I acknowledge the essential role of teacher identity and the need of supporting teachers' identity development, as identified by many researchers, and then focus my work on understanding the sense of identity that our CS teachers hold and ways of supporting their identity development through an intervention program. Next section discusses some unique challenges for developing CS teacher identity and thereby the need of supporting their identity development through professional development programs.

1.1.5 Challenges of developing professional identity as CS teachers

For K-12 CS education, the evolving, young nature of the computing field itself and its educational practice adds a few challenges of its own to the general list of challenges for preparing and supporting teachers. Here, I use *CS teachers* to refer to teachers who teach CS courses at the secondary level. The studies conducted in this work focus on high school CS teachers who teach courses in the Georgia computing pathway. Students who wish to specialize in the computing pathway take four CS courses: Computing in the Modern World, Beginning Programming, Intermediate Programming, topics in Computer Science including AP CS course [5]. This curriculum was created based on the ACM Model Curriculum for K–12 Computer Science (Tucker, et al., 2006).

---

[5]Computing pathway: http://public.doe.k12.ga.us/ci_cta.aspx?PageReq=CICTAPathways3.

The Computing in the Modern World provides students with an introduction to the principles of computer science and its place in the modern world. The Level III ACM model curriculum course standards were split between the Beginning Programming and Intermediate Programming courses (Ericson, et al., 2008).

Although this work is contextualized in the state of Georgia, the overall challenges for CS teachers discussed here are similar to CS teachers in most states in the U.S. Under the current educational system, CS teachers face multiples challenges, which makes it difficult for these teachers to develop a strong sense of identity as CS teachers:

- The evolving nature of the computing field

First, the relative newness and evolving nature of the computing field itself brings big challenges for teachers to identify the subject matter (what they are teaching). It is difficult even for computer scientists to clearly define its contents and boundaries (P. Denning, 2005; P. J. Denning & Rosenbloom, 2009; Shackelford, 2005), let alone secondary teachers who often have a minimal formal education in CS. The study of computer science as a scientific discipline is often confused with other uses of computing technology within education, e.g., computer software applications. Teachers might have their own definitions of computing and their beliefs in the values of computing. As a result, teachers (often with other influences, e.g., administrators) might fail to provide students with access to the key academic discipline of computer science.

- Teacher isolation

Furthermore, since there are still so few CS teachers, these teachers are especially isolated, where often there is no one else in their buildings, or even in their school districts, to discuss issues or ask for any support in teaching CS. This kind of isolation

might prevent teachers building their own sense of belonging and affiliation with other CS teachers.

- Inconsistency in CS teacher certification standards

Thirdly, current certification situation might make it more difficult for CS teachers to identify themselves as CS teachers. As the CSTA reports (Ericson, et al., 2008) point out, we are facing a crisis in CS teacher certification nationally. On one hand, there is a significant lack of consistency in CS teacher certification standards in the US. In many states, a CS teaching certificate is not required in order to teach CS courses (Khoury, 2007). Thus, teachers with little or no CS training are frequently assigned to teach CS courses. New teachers cannot be certified as CS teachers in most states due to the lack of certification program for computing education, so they must meet the certification requirements in some other discipline, in which they might not wish to teach or actually teach. In Georgia, there is no way for a teacher to be certified as a computer science teacher either. Teachers can only add a voluntary computer science endorsement[6] to another teaching certificate such as Business or Mathematics (Ericson, et al., 2008).

- School hierarchy

Similarly to the lack of consistency in CS teacher certification standards, CS courses are often offered in a variety of departments/programs, which do not treat computer science as an individual academic discipline. In Georgia high schools, CS courses are offered in the Business program under the Career, Technical & Agriculture Education (CTAE) division. Teachers with a Business Education or Math Education

---

[6] See http://www.gapsc.com/TeacherEducation/Rules/Rules.asp for more information on this endorsement.

certificate, or the CS endorsement can teach AP CS A. This kind of confusing and complex certification process and school hierarchy make it difficult for CS teachers to recognize the values of teaching CS and identify what they are teaching as well as what kind of teachers they are.

In summary, CS teachers are facing unique challenges in their teaching profession. They might have limited training/educational background in CS, with certification in another field other than CS for their teaching in CS, located in a non-CS department, often isolated and lacking communication with other CS teachers. They might have shallow views about the field of computing and the values of computing. With these multiple challenges CS teachers are facing, it is not surprising for us to hear that CS teachers claim themselves as math teachers, business teachers, technology teachers, etc. Such identities can be indicated in many aspects of their teaching lives. For example, some teachers might still teach computer applications instead of programming in computing pathway courses. Some teachers do not see CS as an important discipline and treat it a supplement/extension of another subject like math and business. Thus, when a math teacher teaches both AP calculus and AP CS, she might encourage her *smart* students to go into her AP calculus course other than the AP CS course if time conflicts. Such observations suggest a potential problem with CS teacher identity. In addition to great efforts in recruiting and (re)training CS teachers, we also need to devote our efforts to supporting their identity development as CS teachers who value and are committed to their teaching of CS.

The potential importance of teacher identity in influencing teacher motivation and commitment as well as in shaping their teaching practice suggest us to examine

teacher identity for CS teachers: what kind of professional identity do current CS teachers bring with into their CS courses and what do those identities mean in their teaching practice? What contributes to the variety of identities they perceive? How do we offer support for their identity development as CS teachers? This thesis attempts to gain initial understanding about these questions.

1.2 Research Questions

In this work, I pose three broad research questions which are investigated through two studies:

- Study 1: Understanding CS teacher identity
    - RQ1: What kind of professional identities do secondary computer science (CS) teachers bring into their teaching practice?
    - RQ2: What influences teachers' sense of identity as a CS teacher?
- Study 2: Supporting CS teacher identity development
    - RQ3: How does the participation with a focus on reflection within a local CS teachers' community (DCCE) influence CS teachers' perceptions of their professional identity?

1.2.1 Understanding CS teacher identity

At the first step, I would like to understand what kind of professional identities CS teachers bring into their teaching in CS (RQ1) and what contributes to their sense of identity as CS teachers (RQ2). Here, I use a blended framework of identity constructs (see more discussion about related work on identity constructs in section 2.1.3) to examine CS teachers, informed by the theoretical framework of social identity (Pennington, 2002), mathematics identities (Martin, 2000) and

science teacher identity (Luehmann, 2007). In this work, I examine what kind of teacher CS teachers self-identify they are. In addition to their self-identification, I look at the specific aspects of their perceptions about teaching CS. Acknowledging the challenges current CS teachers are facing (discussed in section 1.1.5), I adopt the social perspectives of identity and extend the three dimensions of identity into five concrete facets of their belief systems (as teacher identity features). As summarized in Figure 1, I examine CS teacher identity in terms of the following five aspects within three dimentions:

- Attitudes and Values: Interest & value, confidence

This element involves teachers' attitudes and values related to learning CS and towards teaching CS: their interest in teaching CS and their beliefs in the values of teaching CS; their beliefs in their own abilities to teach CS.

- Motivation and Commitment: Learning/strives to teach well, retention/commitment

This element examines teachers' motivational dimension related to their teaching in CS, especially their sense of motivation to strive to teach CS well, their willingness to continue to teach and invest efforts in their computer science courses (e.g.., recruit students to grow the CS program in their schools).

- Belonging/Affiliation: Community/Sense o f belonging

This element examines teachers' sense of awareness and ownership of being a member of a certain social group related to their teaching in CS (e.g., a member of a CS teacher community).

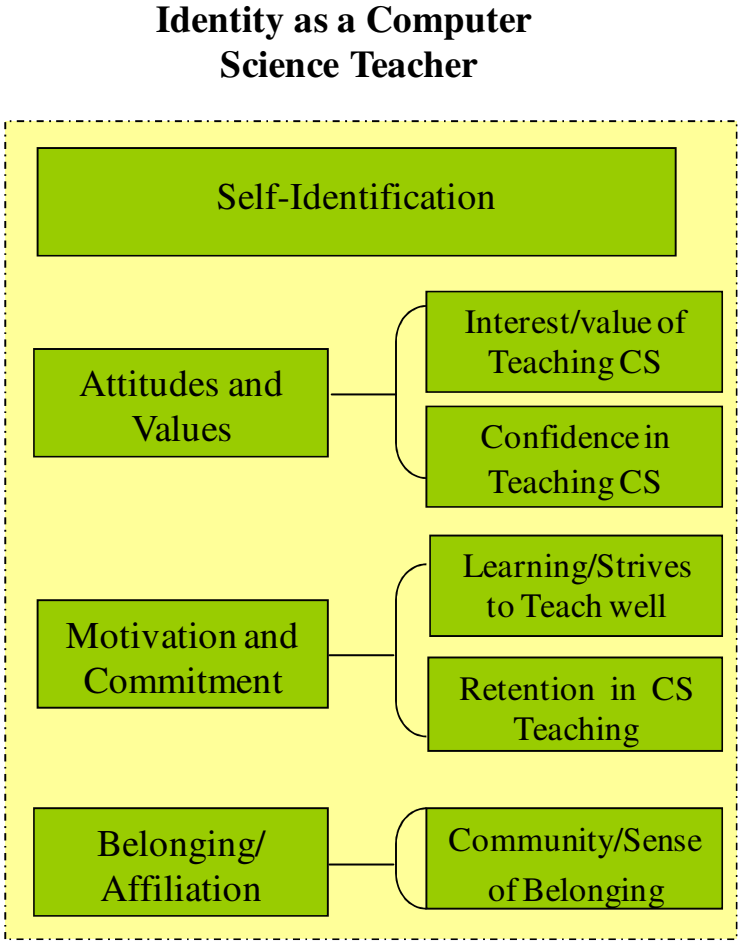


Figure 1: CS Teacher Identity Construct

The first study investigated the first two research questions through interviews with existing CS teachers. I specifically examined teachers' self-definition of who they are in their teaching profession, examining their sense of identity related to their teaching in CS, indicated in the above three aspects of teacher identity features. Furthermore, I explored the social, cultural contexts that might contribute to shaping these perceptions from CS teachers. Through this study, I identified different self-identifications and identity features of current CS teachers who saw themselves as a CS teacher, as a Business teacher, or as a teacher in both CS and another subject. Meanwhile, I identified

four major factors that contributed to these teachers' perceptions about their own teacher identity related to CS teaching: teachers' educational background and certification, CS curriculum and department hierarchy, the availability of CS teacher community, and teachers' perceptions about the field of CS. These results indicate that teacher identity can be a significant issue for CS teachers under the current educational system.

1.2.2 Supporting CS teacher identity development

Informed by the social perspective of identity and identity development, viewing identity as a result of participation in affinity groups, or Community of Practice (Gee, 2001; Lave & Wenger, 1991), this work attempts to facilitate the creation of a CS teacher community and examine the influence of that community on their sense of identity as CS teachers. Study 2 explored how the participation with a focus on reflection within a local CS teachers' community influenced CS teachers' perception of their professional identity.

I first designed a professional development program, the Disciplinary Commons for Computing Educators (DCCE), which had a major focus on promoting teacher reflection and community building. Through the collaborative creation of course portfolios, peer review and peer observation, DCCE offered opportunities for teachers to explicitly reflect on their teaching in CS, as well as to narrate, question, interpret, and thus recognize and even revise their goals, assumptions and theories implied in their teaching. This is a central process of identity building through their participation within a community of practice (Wenger, 1998). I conducted case studies with four CS teachers who participated in DCCE over a period of one year and traced their sense of identity

along with their participation and half year later. I identified different self-identity statuses and change trajectories from these teachers.

The results from this study indicate that the use of the DCCE program in promoting community building and teacher reflection can have an impact on secondary CS teachers' identity development (and thereby help them become committed, qualified CS teachers). Based on the findings from this study, I proposed a potential model of supporting CS teachers' identity development, with the mapping between characteristics of the professional development (PD) program (DCCE) and particular facets of CS teacher identity. Overall, the DCCE program provided an inviting context for teachers to explore their identity and achieve a sense of identity as a CS teacher. For example, participants were able to affirm their own good practices, see similarities among each other's teaching, identify ways of improving and get inspired to grow their CS programs. These affordances supported their identity development as CS teachers by helping them become more confident in teaching CS, get encouraged and inspired to learn to teach better, as well as become more committed to teaching CS. Meanwhile, they were able to build a sense of belonging to a group of CS teachers after actively participating in this community. In this group, they were able to build connections with other motivated CS teachers, see similarities among themselves and learn from each other as peers.

1.3 Document Overview

This dissertation is made up of five chapters beyond this introduction: Chapter 2 synthesizes relevant work on teacher identity and identity development that informs my studies of CS teacher identity. Chapter 3 outlines study 1, which is aimed at gaining initial understanding of the teacher identities CS teachers hold and bring into their

teaching in CS, and what contributes to the variety of identities they perceive. Chapter 4 introduces the design of the teacher professional development program (DCCE) intended to influence CS teachers' sense of identity. Chapter 5 outlines the study designed to explore the ways the intervention program (DCCE) has influenced CS teachers' sense of identity. Finally, chapter 6 revisits and extends some of the findings presented throughout the dissertation, with discussion on the potential contributions made by this work and future research directions.

CHAPTER II BACKGROUND AND RELATED WORK

This chapter summarizes related work drawn from a variety of literature that informs this work. First, I will introduce the theoretic framework of teacher identity, summarizing what we know about identity, teacher identity and identity formation. Then I will discuss related work on facilitating teacher identity development that informs the design of the second-year DCCE teacher cohort.

2.1 Teacher Identity Theory

This section summarizes how the theories of and related work on (teacher) identity offer a conceptual framework for us to study CS teachers. First, I will discuss the meanings of identity and how we develop our identity, from both psychological and social perspectives. Second, I will introduce related work on teacher identity, including how we define teacher identity and the role of reflection in teacher identity development. Third, I will discuss insights and methodologies for examining teacher identity.

2.1.1 Identity and identity development

In earlier literature, the concept of identity was often vaguely described in terms of "the self" and one's self concept by psychologists (Erikson, 1968; Mead, 1934). More recent views acknowledge the different roles or ways of being specific to a certain context or community. Identity development can be best characterized as an ongoing process, a process of interpreting oneself as a certain kind of person and being recognized as such in a given context (Gee, 2001). This process of developing self concept is achieved through a process of ongoing reflection and observation, allowing individuals to

go through a process of exploration and forming commitment to who they are (Erikson, 1968).

Examining an individual identity places the unit of analysis on the individual's belief systems, the socio-cultural perspective of identity suggest us to look closer at identity and identity formation in a specific context. In particular, Gee (2001) defines identity as being a certain kind of person in a particular context. He suggests understanding identity by focusing on the different roles people take on depending on the context. He identifies four ways to view identity: nature-identity, institution-identity, discourse-identity and affinity-identity.

- Nature-identity

One's nature identity stems from one's natural state that the individual has no control, e.g., being an identical twin.

- Institution-identity

This type of identity is derived from a position authorized by authorities within institutions. For example, being a professor in College of Computing at Georgia Institution of Technology is an institution-identity.

- Discourse-identity

Discourse-identity is an individual trait recognized in the discourse/dialogue of/with individuals. For example, being a charismatic person is a discourse identity that is achieved through interactions with other individuals. It is because other people treat, talk about and interact with this person as a charismatic person that she is one.

- Affinity-identity

Affinity-identity is determined by one's practices in relation to a certain social group (e.g., church, academic organizations).

In particular, Gee defines a (capital D) Discourse as any combination of speaking, and writing, acting and interacting, using face or body, dressing, feeling, using tools or technologies, believing and valuing in a certain way that get one recognized as a certain "kind of person". Thus, Discourse suggests a way of recognition of one's identity by examine the combination of different aspects. However, as computing education is relative a new field, it is hard to define the Discourse of CS teachers. While we don't know what will be the unique Discourse of high school CS teachers, we can be sure that a subset of CS discourse/language (e.g., "array" and "recursion") and some of high school teacher discourse ("lesson plans" and "CTAE") will be included in high school CS teacher discourse. In this work, I started with examining the Discourse of CS teachers focusing on teachers' beliefs and feelings related to their CS teaching.

In addition to Gee's contribution to the theory of identity from social-cultural perspective, the situated perspectives of identity further expanded the idea of identity development through examining identity development within a community of practice (CoP) (Wenger, 1998). Wenger views identity as a product of individuals' participation in CoPs. In presenting identity in terms of belonging to a community of practice, Wenger addresses three modes of belonging that are involved in forming an identity with respect to the community: engagement, imagination and alignment. Engagement is active involvement in mutual processes of negotiation of meaning. Imagination refers to a process of creating images of the world and ourselves by extrapolating from our own experience. Alignment then coordinates our energy and activities to reach our imagined

identity. Similarly, Gee (2001) suggests that each individual has an affinity-identity which is formed as a result of participating in an affinity group, analogous to Wenger's community of practice. What people in the group share is allegiance to, access to, and participation in specific practices that provide each of the group's members the requisite experience. This power works through the process of participation or sharing among the group (Gee, 2001).

The above situated theory of identity formation suggests the potential role of participation in supportive communities for an individual's identity building. It also points to the central roles of reflection on individuals' participation and on their practice in identity formation. These perspectives of identity formation inspire my work to focus on creating a community of computing educators with a focus on reflection, in order to support teachers' identity development (as CS teachers). Meanwhile, viewing identity as a product of participation in CoPs also suggests the investigation of how teachers' prior experiences in local communities influence their sense of identity. The social, cultural and educational contexts of their teaching practice, such as teachers' prior educational background, teaching experiences and school contexts, can play a role in forming teachers' sense of identity.

2.1.2 Teacher identity foundations

- **The meanings of teacher identity**

As discussed in Chapter I, much recent literature on teacher education highlights the importance of identity in teacher development (Beauchamp & Thomas, 2009; Sachs, 2005). Meanwhile, the concept of teacher identity is used in different ways in the domain of teaching and teacher education with different emphasis. In some studies, teachers'

perception of professional identity is studied from a personal teachers' knowledge perspective, which explores the ways teachers see themselves as subject matter experts, didactical experts and pedagogical experts (Beijaard, Verloop, & Vermunt, 2000). In some other studies, teacher identity refers to the influence of the conceptions and expectations of other people, including broadly accepted images in society about what a teacher should know and do. It also refers to what teachers themselves find important in their professional work and lives based on their experiences in practice and their personal backgrounds (Beijaard, et al., 2004; Tickle, 1999). More broadly, teacher identity is characterized by the way teachers think about themselves, the images they have of "self". It provides a framework for teachers to construct their own ideas of 'how to be', 'how to act' and 'how to understand' their work and their place in society (Beauchamp & Thomas, 2009).

- **Teacher identity formation**

Teacher identity formation reflects a subtle dimension of the complex and ongoing process of self-discovery, a process for teachers to know themselves, their students, and the subject matter they teach (Cardelle-Elawar, Irwin, & Sanz de Acedo Lizarraga, 2007). Teacher identity formation is often presented as a struggle because teachers have to make sense of varying and sometimes competing perspectives, expectation, and roles they have to confront and adapt to. This perspective of teacher identity is consistent with the situated perspective of identity, which recognizes identity formation as on ongoing process of exploration. First, student teachers must undergo a shift in identity as they move through programs of teacher education and assume positions as teachers in challenging school contexts. Second, further identity shifts may

occur throughout a teacher's career as a result of interactions within schools and in broader communities.

Researchers believe that multiple social, cultural contexts, such as school environment, students, colleagues and school administrators, can all be influential in shaping teacher identity (Beauchamp & Thomas, 2009). Prior studies find that the three types of factors (perceived organizational politics/teaching context, teaching experience and background) play a major role (Beijaard et al, 2000; Chan etc, 2008). Furthermore, reflective dialogue among teachers also has a positive impact on strengthening teachers' sense of identity (Chan etc, 2008). Some literature also suggests that the choice of teaching discipline may also affect identity, as disciplines may tend to have particular teaching cultures of their own (Beauchamp & Thomas, 2009; Pennington, 2002).

- **Teacher identity and reflection**

Reflection is seen as a key component associated with the concept of teacher identity. Teachers use reflection to reach understandings about their identity. In other words, it is impossible to speak about the self when there is no reflection. To develop the self as a teacher, Antonek et al. (Antonek, McCormick, & Donato, 1997) emphasize the need to develop reflective skills for teachers to be able to identify their own sense of identity. Through self-reflection, (student) teachers relate experiences to their own knowledge and feelings, and are willing and able to integrate what is socially relevant into their images of themselves as teachers (Nias, 1987). Therefore, the PD program in this work, DCCE, attempts to help teachers establish a community where they are encouraged to explore their roles as CS teachers through reflection and peer review on their reflection about their own teaching practice.

- **Four basic assumptions about teacher identity**

As there are varied definitions and ways of exploring identity, there are variations in the meanings of teacher identity as well. In spite of these variations, there are some notable similarities among the literature (Beauchamp & Thomas, 2009). In particular, Rodgers and Scott (Rodgers & Scott, 2008) have nicely summarized that contemporary conceptions of identity share four basic assumptions: (a) identity is dependent upon and formed within multiple contexts which bring social, cultural, political and historical forces to bear upon that formation, (b) identity is formed in relation with others and involves emotions, (c) identity is shifting, unstable and multiple, and (d) identity involves the construction and reconstruction of meaning through stories over time (Rodgers & Scott, 2008). These assumptions are evident in the work of many scholars that I have mentioned earlier about teacher identity and identity formation.

In particular, the fourth assumption—identity as a construction and reconstruction of meaning through story, has been extended by the work of Michael Connelly and Jean Clandinin on narrative inquiry over decades (Clandinin & Connelly, 2000). Their work offers a narrative framework of describing and defining identity, which has become a major method for studying identity. I will further introduce this method in the next section.

2.1.3 Studying teacher identity

The word of identity itself is often a theoretical concept and not easy to measure. Here, I will first summarize ways of operationalizing (teacher) identity from related work, and define the construct of CS teacher identity. Next, I will introduce the narrative inquiry method for investigating CS teacher identity.

- **CS Teacher identity construct**

Although (teacher) identity has been a buzz word in many researches, its constructs are not well defined. In particular, Gee's (2001) definition of identity and his four ways to view identity offers great insights for us to understand the meaning of identity from four different aspects of a person. However, this identity definition does not offer an operationalizable framework to measure identity. Among the few frameworks of identity, the technology identity (Goode, 2010), informed by students' mathematics identity (Martin, 2000), provides an analytical conception. This framework of technology identity includes: beliefs about one's own technology abilities, beliefs about the importance of technology, beliefs about participation opportunities and constraints that exist, and one's sense of motivation to learn more about technology. This framework has explicit focus on four aspects of one's own perceptions about technology and these items can be transferred to identity related to other fields.

For teacher identity, most research stays at the stage of theoretical discussion with very few constructs defined. Some work examines teacher identity focusing on their professional knowledge. Thus, teachers' professional identity will be described in terms of the teacher as a subject matter expert, pedagogical expert and didactical expert (Beijaard, et al., 2000). Some other work embeds with more social perspective of identity. For example, a study of STEM teacher identity for career changers measures identity in terms of four aspects: their engagement in the teaching community, use of teacher language and vocabulary, skills of value in the teaching profession, and their sense of responsibility as a teacher (Grier & Johnston, 2008). This teacher identity construct is

designed for career changers with an emphasis on the transition from being a profession in a STEM field to a teacher of an STEM subject.

A more generalized social identity for teachers includes a teacher's self concept which incorporates three elements related to the participation of a community of practice: a sense of awareness of being a member of a certain social group or groups of teachers, a specific and positive set of attitudes and values related to their group membership, and feelings of solidarity, loyalty and commitment to these groups (Pennington, 2002). Here, I use this overall theoretical framework of social identity to examine CS teacher identity, while also adopting specific items from the technology identity. As presented in Section 1.2.1, CS teacher identity is examined in terms of three aspects of their belief systems: belonging/affiliation to a certain group of CS teachers, their attitudes and values related to learning CS and towards teaching CS (e.g., beliefs about the values of teaching CS and their own ability in teaching CS), and motivation and commitment to stay in this profession. In particular, acknowledging the challenges that our current CS teachers are facing, I adopt the social perspectives of identity and extend the three dimensions of identity into five concrete facets of CS teacher identity (Figure 1). This construct of CS teacher identity includes teachers' self identification and the following five aspects of their perceptions:

- Interest and value: Teachers' interest in teaching CS and beliefs in the values of teaching CS;
- Confidence: Their confidence in teaching CS;
- Learning/strives to teach well: Their willingness to learn and grow the CS program in their department;

- Commitment/retention: Their commitment to continuing to teach CS;
- Community/sense of belonging: Their sense of belonging to a community of CS teachers.

Section 1.2.1 has explained each item of this CS teacher identity construct.

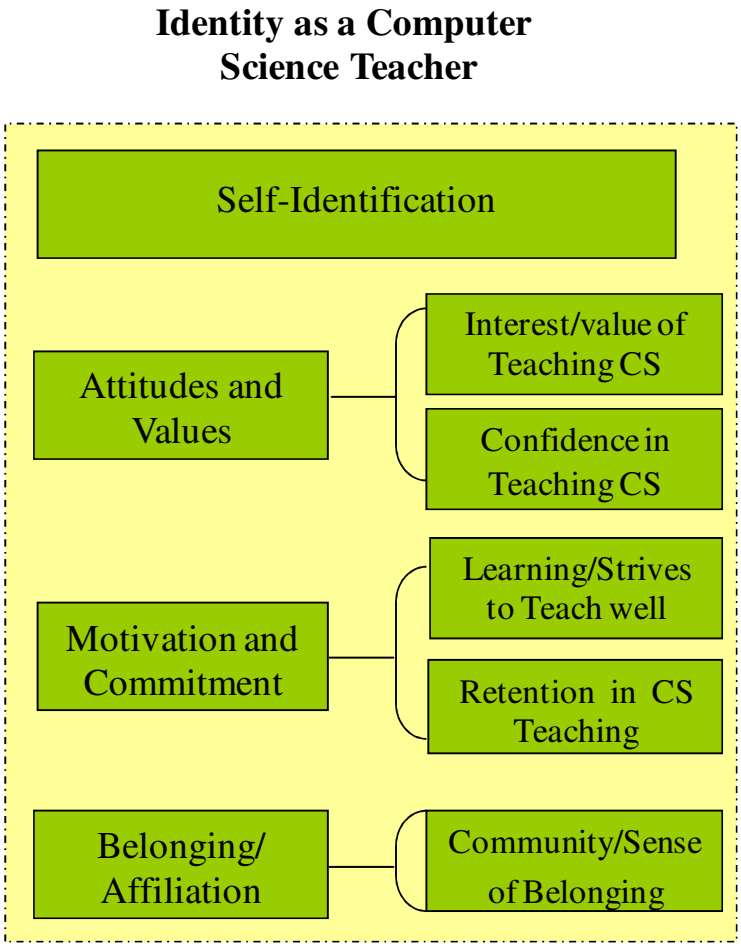


Figure 1: CS Teacher Identity Construct

- **Narrative inquiry**

In the process of understanding (teacher) identity, many researchers recognize the value of using narrative as a methodological approach. Narrative inquiry, a relatively new qualitative methodology, is the study of experience understood narratively (Clandinin &

Connelly, 2000). Narrative inquiry usually begins with telling stories, that is, with a researcher interviewing (Seidman, 2005) with participants who tell stories of their experiences. It suggests collecting multiple field texts as data sources, such as stories, autobiography, field notes, letters, conversations, photos and other artifacts related to their life experiences (Clandinin & Connelly, 2000).

This approach offers an inquiry process of examining teacher identity through analyzing teachers' narrations on their experience as a teacher, including their perceptions about their teaching practices and perspectives on the contexts in which they develop their ideas for teaching (Alsup, 2006; Sfard & Prusak, 2005). Meanwhile, narrative also offers an opportunity for teachers to gain new understandings about themselves. Narratives of teachers can be used to capture the "teacher voice", which may distinguish from other voices, such as educational reformers. researchers and administrators, who speak to who a teacher is (Diamond, 1993).

When examining the development of CS teachers' identities, I used this narrative inquiry method to investigate identities CS teachers held and how they changed through their participation in the DCCE program. Teachers were asked to tell their stories about their experiences as CS teachers through interviews at different time. In particular, teachers in DCCE created course portfolios to narrate their teaching of CS courses. The overall process of analysis is qualitative discourse analysis focusing on the ideas, issues, experience and feelings described by the participants.

In addition to the stories told by CS teachers through in-depth interviews, I also collected relevant artifacts as multiple sources of evidence. I collected a variety of artifacts from these teachers, including the course portfolios they created, peer review

comments, and classroom observation notes. These artifacts were used as additional resources to triangulate my understanding of CS teacher identity from teachers' self-narrations through the interviews. I will discuss more about the specific studies in Chapter 3 and Chapter 5.

2.2 Facilitating Teacher Identity Development

This section discusses two theories that are related to teacher identity development (situated learning and metacognition) and two ways of supporting teacher identity development through facilitating reflection (action research and course portfolio).

2.2.1 Situated learning

As stated earlier, the situated perspective of identity sees identity as a result of participation in CoPs. Identity can be viewed as negotiated experience of participating in a CoP. Thus, we define who we are by the ways we experience ourselves through participation as well as by the ways we and others reify our selves (Wenger, 1998). In other words, CoPs offer the venue for identity formation.

The perspective of situated learning views CoPs as learning communities, where learning occurs through the participation in a CoP (Lave & Wenger, 1991). Situated learning views identity as learning trajectory, from peripheral participation to more central, full participation within the community. Through legitimate peripheral participation, learners move from new comers/apprentices towards master practitioners. In some way, the perspective of situated learning addresses the motivation of identity development. Although gaining task knowledge and skills is important for learning, a deeper sense of the value of participation to the community and the learner lies in becoming part of the community. Moving toward full participation in practice involves

an increasing sense of identity as a master practitioner. This theoretical perspective encourages teachers to participate in learning communities in ways that build their identities as master CS teachers.

The theory of situated learning also emphasizes the importance of transparent access (Lave & Wenger, 1991). The example of the butchers illustrates that apprenticeship could prevent learning rather than facilitate learning, when it denies the access to the activities of mature practice in the community. Becoming a full member of a CoP requires access to a wide range of ongoing activity, old-timers, and other members of the community, and to information, resources, and opportunities for participation. Therefore, to be able to facilitate our CS teachers to build their sense of identity, an ideal community of computing educators needs to offer access to resources and opportunities for teachers' participation in this community.

Furthermore, Gee (2005) define efforts to make visible to self and others who one is and what one is doing as *recognition work*. Recognition work is a necessary process of identity development. Although participation is essential for learning, learning as identity development occurs in the interpretation, narration and thus recognition of that participation by self and others. Therefore, offering opportunities for recognition work is critical for supporting identity development. In this work, I take this insight as one major rationale that guides the design of the second-year DCCE program for supporting CS teacher identity development.

2.2.2 Metacognition and self-regulation

Another concept related to facilitating identity formation is metacognition. Metacognition refers to knowledge concerning one's own cognitive processes, and the

active monitoring and consequent regulation of these processes in the pursuit of goals or objectives (Bruning et al., 2004; Zimmerman et al., 2005). Identity formation involves individual process of identification and negotiation among their participation in CoPs (Wenger, 1998), which requires metacognitive process of reflection, monitor and regulation. The process of identity building is a reflective, self-regulatory process, through which creates and clarifies meaning in terms of self, and result in a changed conceptual perspective. Therefore, there is a need to foster reflective, self-regulative learning for teachers.

2.2.3 Mechanisms for promoting reflection

As discussed in above sections, theories about identity and identity formation tell us that reflection is critical for forming identity. This section discusses two mechanisms (action research and course portfolio) that we can implement to promote reflection, thereby promoting the development of teacher identity. In particular, action research was experimented in the pilot DCCE teacher cohort. Course portfolio was used in the second year DCCE, where study 2 of this work was conducted.

- **Action Research**

One way of promoting reflection and teacher learning is action research. Action research is broadly defined as a form of self-reflective inquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practices, their understanding of these practices, and the situations in which the practices are carried out (Carr & Kemmis, 1986). Teachers' action research (also often called as teacher research) is a form of inquiry that involves teachers in developing their own research questions and investigating their own classroom practices (Zeichner & Klehr, 1999).

Related work on teacher research reports that teacher research is a valuable form of professional development, which leads to sustainable teacher learning (Bransford, Brown, & Cocking, 2000; Elliott, 2001; Zeichner & Klehr, 1999). Through explicit inquiry and critical reflection on their own teaching practice, action research provides opportunities for teachers to develop pedagogical content knowledge, refine beliefs and activities around teaching and to gain confidence in promoting student learning (Lundeberg, Bergland, Klyczek, & Hoffman, 2003; Zeichner, 1997; Zeichner & Klehr, 1999).

- **Course Portfolio**

Another way of promoting teacher reflection and identity building is the use of teaching portfolios. Broadly defined, a teaching portfolio is "a factual description of a professor's strengths and accomplishments. It includes documents and materials which collectively suggest the scope and quality of a professor's teaching performance" (Seldin, 1993). Portfolios at their best are more than collections of teaching artifacts (i.e., syllabi, assignments, evidence of student learning). They include analysis and reflection; they put forward an argument, make a case, summarize and explain an inquiry into teaching and learning. The course portfolio, focusing on the unfolding of a single course, is viewed as a superb mechanism for reflection on and improvement of one's teaching practice (Hutchins, 1998). Course portfolios typically include certain learning goals, its content and structure, teaching strategies, assignments intended to accomplish those goals, and learning outcomes (Cerbin, 2001). Literature on course portfolios has shown clear benefits for a teacher in preparing a course portfolio, primarily through making course objectives explicit, reflection on rationales, and systematic study of student learning

(Cerbin, 2001). The second round of DCCE used course portfolio creation as a major mechanism to drive CS teachers' reflection on their own teaching practice.

2.3 Disciplinary Commons

This section introduces the Disciplinary Commons project, which offers a model of using course portfolio to support reflection and community building for computing educators. The second-year DCCE adopted the main agendas for organizing its teacher cohort.

The Disciplinary Commons project is designed to encourage educators within the field of computer science to document and reflect together about their teaching practices. It has two primary objectives: the first is to document and share knowledge about teaching and student learning on computer science courses; the second is to establish practices for the scholarship of teaching by making it public, peer-reviewed, and amenable for future use and development by other educators (Fincher & Tenenberg, 2007; Tenenberg & Fincher, 2007). The mechanism for achieving these goals is through a series of monthly meetings involving a number of CS faculty teaching a same course at different institutions talking about their teaching practice, with each person documenting their teaching in a course portfolio.

Through participation and reification within a community of practice, participants in previous Disciplinary Commons project reported all kinds of values of Disciplinary Commons, including offering opportunities to systematically reflect on teaching practice, to exchange concrete ideas for teaching their courses with other CS educators, and learn skills that apply directly to their teaching practice (Tenenberg & Fincher, 2007). Overall, the course portfolio serves as a vehicle for personal reflection

and community building through collaboration (from unpublished Disciplinary Commons evaluation report summary, 2009).

The Disciplinary Commons project has been designed and repeated for several cycles at different locations focusing on different concrete courses. Although work on the Disciplinary Commons does not explicitly examine CS teacher identity, it offers a successful model for organizing professional development programs that use course portfolio to support reflection and community building for computing educators.

2.4 First-year DCCE Experience

The first run of DCCE adopted action research as our mechanism for promoting teachers' reflection and understanding on their teaching practice. Eight computing instructors (five HS teachers and three college faculty) participated in the first-year DCCE teacher cohort. They met on Saturdays in a series of six monthly meetings to share practices and conduct brief action research projects. Table 2 describes the meeting agendas for the first DCCE teacher cohort.

The agenda for each meeting was participant-driven in terms of choosing discussion topics, defining action research project ideas and coordinating project process. During the first-year DCCE, three researchers of this project including myself worked together as leaders to plan and organize the meetings and to offer support for teachers' action research projects. At the end of the year, two participating teachers volunteered to be the leaders for the second year's group with new participants. These two teachers (one HS teacher and one college faculty) worked with me as teacher leaders organizing meetings in the second-year DCCE program.

Table 2: First-year DCCE Meeting Agendas

Date	Topic	Homework
January 10, 2009	Introduction Challenges and Concerns for Computing Educators Lessons from Computing Education Research	Reflection on Current Teaching Action Research Projects Ideas
February 7, 2009	Participant-led Discussion: Computing Curriculum in HS and College Project Examples & Research Methods Project #1 Group Forming and Plan	Project #1 Data Collection
March 14, 2009	Project #1 Data Analysis and Reflection Project #2 Idea Brainstorming	Ideas for Project #2
April 18, 2009	Participant-led Discussion: IT Curriculum Project #2 Design and Plan	Project #2 Data Collection
May 16, 2009	Participant-led discussion: HS Extra Curricula Activities Project #2 Analysis and Reflection	Project #2 Data Collection (Continue)
June 6, 2009	Participant-led Discussion: Pair programming Project #2 Report and Reflection (Continue) DCCE Reflection and Evaluation	Participation in DCCE Evaluation Interviews

At the end of the first-year DCCE program, preliminary evaluation data were collected through post-workshop surveys and interviews with participants. The evaluation results showed that participants from the first DCCE enjoyed the activities of communicating with other introductory CS teachers. Participants valued the sessions where teachers themselves led discussions on topics they were interested and had experiences in. They also reported gaining further understanding about the issues of their interests through collaborative study on their own classrooms. Meanwhile, participants

also valued the benefits of getting connected with other teachers and working as a group (Ni, Guzdial, Tew, & McKlin, 2011).

Meanwhile, the participants also experienced some big challenges during their participation of action research:

- Especially, these teachers struggled with learning techniques of research methods, especially those who had very few experience in conducting educational research.
- Secondly, it turned out to be a big challenge for the participants to come up with their own guiding questions to study. Although the researchers modeled a first run of studies with research questions and study methods training, some of the participants still found it very difficult to come up with a question they wanted to explore by themselves for the second study.
- Thirdly, most of these participants were not familiar with the exercise of doing reflection on their own teaching. While the teachers were busy with attempting to complete the studies, very few of them actually exercised deep reflection on the findings and its implications for their teaching. During the last meeting, the researchers developed a reflection sheet with prompt questions and example answers to guide our participants' reflection. Participants reported that this tool was helpful and they were able to think about the implications of their findings for their teaching practice.

Although the first DCCE teacher cohort was not explicitly designed to support identity development for CS teachers, the experiences of designing and organizing this first teacher cohort offered insights for the second DCCE teacher cohort. From the first

DCCE, I learned a few lessons and strategies for supporting teachers for reflection and community building:

- Studying and reflection on their own teaching practice is not necessarily an existing habit in teachers' life. We need to explicitly offer opportunities for teachers to practice, starting with asking questions about their own teaching.
- Action research can be very challenging for teachers with limited experiences and training of doing action research. We will need to provide some training related to research methods and offer further support throughout their action research process.
- We also need well-structured tools to scaffold teachers' reflection activity. For example, one strategy can be offering worksheet with prompt questions to guide teachers' consideration of the implications of the project findings for their own teaching.

2.5 Chapter 2 Summary

In this chapter, I have summarized theories and related work that inform my study of CS teacher identity. I discussed meanings of teacher identity and the key role of reflection in teacher identity development, informed by related identity theories. I then defined a CS teacher identity construct and introduced the narrative inquiry method for investigating CS teacher identity. I also discussed action research and course portfolio as two mechanisms for promoting teacher reflection. I decided to adopt course portfolio in the second-year DCCE for promoting teacher reflection, thereby supporting CS teachers' identity development. I also borrowed experiences and insights from previous work, the Disciplinary Commons and the first-year DCCE, to inform the design of the second-year

DCCE program as my intervention for supporting CS teachers' identity development. I will further introduce the design of the second-year DCCE in Chapter 4.

Chapter 3 will outline the first study of this work, which examines what kind of teacher identities current CS teachers hold and what contributes to their sense of identity as a CS teacher.

CHAPTER III STUDY 1: UNDERSTANDING CS TEACHER IDENTITY

As discussed in Section 1.1.5, CS teaches are facing unique challenges in their teaching profession. Examples of these challenges include: the field of computing is evolving; CS courses are often offered as electives in a non-CS department; Many CS teachers do not have formal training in CS; they are often isolated. Surrounded with these challenges, teachers do not have typical contexts for developing a sense of professional identity for their CS teaching, such as a CS teacher certificate and a computing department that they can belong to.

The first study of this work is an exploratory study that consisted of an interview with CS teachers. As introduced in Chapter 1, the primary research questions addressed by this study are listed in Table 3. This study is intended to gain initial understanding of CS teachers' perceptions about their own professional identity and factors that might contribute to these perceptions. Findings of study 1 offer insights on how to support CS teachers' development of their professional identity (study 2).

Table 3: Study 1 Research Questions and Method

Research Question	**Data Collection**	**Participants**
RQ1: What kind of professional identities do secondary computer science (CS) teachers bring into their teaching practice?	Pre-DCCE Identity Interview	Local high school teachers teaching CS courses
RQ2: What influences teachers' sense of identity as a CS teacher?		

3.1 Participant Recruitment

I recruited ten CS teacher participants for this study from high schools at the greater Atlanta metropolitan area. Among these ten teachers, one participant was unable to participate in the whole study. The interview with her was interrupted and we were unable to finish it later on. Therefore, data from nine participants were analyzed in this study. These nine teachers taught at least one introductory CS course listed in the Georgia computing curriculum: Computing in the Modern World (CiMW), Beginning Programming (B-Prog), Intermediate Programming (I-Prog) and AP CS. Recruitment solicitation was distributed in target communities (e.g., the CS teacher mailing list created by the Institute of Computing Education, mailing list of CS teachers in local counties by asking permission from gatekeepers). A sample of the recruitment text is available in Appendix A.1.

3.2 Study Method

This study consisted of two parts. First, participants completed a demographic questionnaire. Then, I conducted an open-ended interview with each participant. I also asked the interviewee to provide some artifacts that were mentioned or relevant in the interview, such as a course syllabus and a lesson plan for a specific unit.

The participant background survey collected basic background information of these teachers (e.g., age, educational background, teaching experience in general and in computing). It also collected information about participants' teaching context related to their teaching of CS (e.g., school size, CS course offered, work load, student demographics, located department, etc). Furthermore, I collected information about their professional life (e.g., professional communities they attended, professional development

experience, certification gained for teaching CS courses). The full questionnaire is attached in Appendix A.2.

The semi-structured interview lasted around 60-90 minutes regarding participants' sense of identity. The interview protocol is attached in Appendix A.3. The participants were first asked to introduce themselves in terms of who they are and what they teach. I then asked them to tell the stories of how they started teaching CS, their understanding of the subject they teach (computing) and many other aspects of their teaching lives, such as their teaching goals, teaching context, issues and challenges they face in teaching CS, and their participation in professional communities. I also explicitly asked these teachers to explain why they had those perceptions, or what contributed to those perceptions.

3.3 Data Analysis

The interviews were conducted at the beginning of Fall 2009 before the 2009-2010 DCCE teacher cohort started. The results of the participant background survey are summarized as background profiles in Section 3.4. This information was used to support the analysis of the data collected from the CS teacher identity interview.

The interviews were audio recorded and transcribed. The interview transcripts were analyzed in terms of the sense of identity teachers perceived and their stories of what contributed to those perceptions. The process of analysis is a conceptual qualitative discourse analysis focusing on the experiences, feelings, and beliefs described by the participants. The analysis on their sense of identity first focused on their self-identification about who they are. I coded their self-identification as teachers who self-identified as CS teachers, teachers of subject(s) other than CS, and teachers of multiple subjects including CS. I further traced their CS teacher identity as indicated in the three

aspects of identity (attitudes and values, motivation and commitment, belonging/affiliation). Then I examined the reported influencing factors for their identity building. Specifically, I looked at how these teachers explained their beliefs/attitudes and why they had those perceptions.

3.4 Participant Background

Eight of the nine teacher participants came from public schools at the greater Atlanta metropolitan area and the ninth teacher taught at a private school in Atlanta. Their teaching experience in CS courses varied from two years to over ten years and their school accommodated from less than 500 students to over 2000 students. Among the public schools in Georgia, CS courses are offered in the Business and Computer Science program under the CTAE (Career, Technical and Agricultural Education) department. In the one private school, CS courses were offered in the Business and Computer Technology department, which served students similarly as the Business and Computer Science department in public schools. Therefore, there is no big difference in terms of where those courses were offered in different participants' schools.

Table 4 lists these nine high school CS teachers' professional background information including their educational backgrounds, teaching certificate(s) they held, the CS courses they were teaching and professional communities they attended. All the teacher names mentioned in this document are pseudonyms. First, these teachers reported that they all taught at least one of the introductory CS courses listed in the Georgia computing curriculum for the computing pathway. One teacher (Rose) only taught the Computing in the Modern World course. Seven other teachers taught at least one or more advanced courses (Beginning Programming, Intermediate Programming and AP CS). In

particular, another teacher taught the Interactive Media Pathway[7], which is deigned for those students who want to pursue future careers in interactive media. He claimed that interactive media belonged to CS and he himself was a CS teacher.

Table 4: Study1 Participants

Participants	CS courses	Educational Background	Certificate	Professional Communities
Alex	CiMW, (Advanced &) Web Design, Introduction to Animation in 3D	Electrical Engineering, Management	Technology Education, Math Education, Business Education	GACTE, PAGE
Becky	CiMW, B-Prog, I-Prog, AP CS	Computer Information System	Business Education	NBEA, CSTA, GACTE
Bob	CiMW, B-Prog, AP CS	Computer Information Systems, Currently in Math Education	Technology Education, Business Education	GACTE
Ryan	Programming in VB, C++ & AP CS in Java	Political science, Private school leadership	N/A	ISTE. NECC
Cindy	CiMW, B-Prog, AP CS	Math Education	Math Education	NCTM
John	AP CS	CS and Math, Math Education	Math Education	GCTM
Pat	CiMW, B-Prog, I-Prog, AP CS	Business	Business Education	CSTA, ACTE
May	CiMW, B-Prog (planning)	Management, Elementary Education	Business Education	None
Rose	CiMW	Business Education	Business Education	GACTE

As we can see from Table 4, the participants had different educational backgrounds, such as Mathematics (Education), Business Education, Management,

[7] Recommended by the Georgia Department of Education, students who wish to specialize in the interactive media career pathway take four courses: the Computing in the Modern World, Fundamentals of Web Design, Advanced Web Design and Introduction to Animation and 3D Design.

Political Science, and Computer Information Systems (CIS). Among these nine teachers, three of them held a computing related degree: one in CS and two in CIS.

As to the certification status, one teacher (Ryan) did not pursue a teacher certificate since that was not required to teach at a private school. Six of the remaining eight teachers got a Business Education certificate, which allowed them to teach CS courses in Georgia. Both of the two teachers (Cindy and John) holding a Mathematics degree got a Mathematics Education certificate. These two teachers reported that they belonged to the Math department in their schools, while the other six teachers holding a Business Education certificate all belonged to the Business and Computer Science program/department in their schools.

These teachers also reported briefly about what kind of professional communities they joined. Overall, the two teachers (Cindy and John), who also taught Math courses, mainly joined Mathematics teacher communities, such as the Georgia Council for Teachers of Mathematics (GCTM) and National Council of Teachers of Mathematics (NCTM). They further reported that they regularly (several times each semester) visited the websites of these two communities for resources. John also attended a local Math teacher community's professional development activities (in the format of workshops) in his county in the past two years, which was hosted by a local research university. The Business Education certificated teachers mainly joined professional communities for Business teachers locally and nationally, such as the Association for Career and Technical Education (ACTE), National Business Education Association (NBEA), and Georgia Association for Career and Technical Education (GACTE). These teachers also attended the yearly professional development offered by the CTAE departments in a local

county or statewide. In addition, Ryan attended two technology and education communities: International Society for Technology in Education (ISTE) and National Educational Computing Conference (NECC), pursing new ideas and technologies for education. All of these ten participants had attended at least one professional development workshop offered by the Institute of Computing Education, which is a major effort to train high school CS teachers in Georgia.

In summary, these nine participants in study 1 had different backgrounds. The next section (Section 3.5) reports how these teachers identified themselves as teachers in different subjects. Section 3.6 presents how these different backgrounds and other factors might contribute to their self-perceptions as CS teachers (or not).

3.5 Perceived CS Teacher Identity: Self-identification and Identity Features

The participants were explicitly asked to introduce themselves and clarify their own teacher identity. Overall, these teachers self-identified themselves either as a CS teacher, as a Business teacher, or as both a CS teacher and teacher in another subject (Math or Business). Table 5 summarizes the self-identifications and identity features of these nine teachers. The next three sub-sections will present further information about these three kinds of teacher identities and the identity features indicated by the individual teachers (their confidence in teaching CS, motivation to strive to teach well, commitment in teaching CS, and the sense of belonging to a CS teacher community). As they all valued the teaching of CS/Computing, to save space, this item is not listed in Table 5.

Table 5: Summary of Reported Teacher Identity

Teachers	Identity and Identity Features						
	Self-Identity	**Identity by others**	**Confidence of teaching CS**	**Learning/strives to teach well**	**Retention/ Commitment**	**Belonging/ Affiliation**	**Other features**
Alex	**CS**	Computer teacher	Has more ideas than he has the time to implement	Only goes to required training	Sense of crisis as a CS teacher, preparing other certificates	Belongs to technical mailing lists	N/A
Becky	**CS**	Business teacher teaching CS	Struggling with teaching CS	Needs training	Staying in CS for job security	Isolated	N/A
Bob	**Computer**	Engineering teacher; computer person	Confident, but still in his first year of teaching AP	Wants to learn more teaching techniques from Math Ed to use in teaching CS	Likes to teach all CS	In ICE teacher mailing list	Pursued different certificates for teaching CS
Ryan	**Programming**	Elective, advanced teacher	Confident	PD always as goals and interest, with few opportunities	Stays and offers CS courses as long as there is student interest	Wants peer CS teachers	N/A
Cindy	**Math & CS**	Math & CS	More comfortable with teaching Math	Wants more ideas for teaching CS	Likes teaching CS, but wants to stay in Math	Business teachers are not my peers	Enjoy teaching CS
John	**CS & Math**	Math	Feels like he is a better Math teacher than a CS teacher	Interested in learning CS Ed	Prefers to teach all CS	Looking for community specific for CS teaching	More passionate about CS and enjoys teaching CS
Pat	**CS & Business**	Hired to teach CS	Not confident in teaching AP CS	Eager to learn about the AP CS course	Stays and builds an individual CS course	Feels like she is on an island as a CS teacher	Feels a sense of Job security
May	**Business**	Computer teacher	Confident	No need for professional development	Willing to teach any *computing* courses *(applications)*	Isolated, but within CTAE teacher community	N/A
Rose	**Business**	Business	Knows enough to teach CiMW	Teaching programming and AP requires learning	Willing to teach more computer softwares, but satisfied with only offering CiMW	Needs to connect with other Business teachers	Enjoys teaching applications

3.5.1 CS teacher

Four teachers claimed themselves as a CS teacher: Ryan, Becky, Bob and Alex. They used words like "computer science teacher", "computer teacher", and "programming teacher/coach" to introduce themselves.

- **Ryan: Programming coach**

Ryan, the private school teacher, called himself programming teacher or coach. He further explained that he didn't label himself as a CS teacher to avoid confusion about the meaning of "Computer Science teacher".

> *[Ryan]: "I suppose I would lump myself more as a Programming teacher, because that is most of my courses… Mainly because I think people don't understand what it means to be a Computer Science teacher. It means so many different things to different people. You know, in the past when I've said that, people want to talk about typing. I'm like, 'Okay.' That's a skill and a technology, but it's not what I'm teaching actually."*

Ryan also had a broad definition of CS and saw the values of CS for every student. He explained his goals for the CS courses as helping students think and communicate, to better cope with change in the world and eventually for future career success.

> *[Ryan]: "I see Computer Science as the use of technologies to impact the representation of information, to apply processes that save time, or craft new inventions, and using those technologies to benefit any endeavor you might begin. So, it's very broad.*
>
> *… I think CS may be the best minor you can do in college, if you don't want to major in it... A good understanding of computer programming can*

help them succeed in their careers in remarkable ways... At the basic level, it's trying to help students think clearly, and communicate accurately and precisely what's going on in their heads… having a computer that lets them know when they somehow have faulty logic or communicated something unintended to a machine is a great learning experience there… A second goal is to have them glimpse more where that can be useful… I want them to see a relationship between the writing of programs and the other fields that they are going to study with the passions they have. There's one more overall goal, I guess, which is learning to cope with change effectively. So, if they can learn how to learn on a machine, and how to experiment, and tinker, they will be well-served the rest of their lives as they tackle any subject, but especially computers, because of how frequently those shifts are."

As the department chair, he built four CS courses in his school, from Introductory Programming, AP CS, Data Structures and one senior design course. He was confident in teaching those courses. He reported that, although he didn't have a CS background, the CS courses he took in college provided some foundation for him and he was a good self-taught learner in learning new tools and technologies. Meanwhile, he also reported he was eager to learn more to be a better teacher and he really hoped to have a group of peer CS teachers.

[Ryan]: "Honestly, the most difficult thing I've had, with at least my journey, has been when machines don't quite handle the software interface and it changes… Also [I had] some issues with language and

paradigm shifts when it went from procedural to object-oriented. There was an interesting journey there of trying to navigate that. That would have been probably better done if I had initiated more contact with other teachers and had a group to work with… It's so important to have a group of peers that you have collaboration with. That's not just a muse group on the Internet. [That's a group] you actually have some meetings with from time-to-time or you co-teach a unit at some school [with], or have a special program in the afternoons."

- **Becky: CS teacher**

Becky self-described herself as a CS teacher since she taught all CS courses (CiMW, B-Prog, I-Prog and AP CS). She had been teaching CS for eight years since she had started her teaching career. She reported that the incentive for her to start and stay in CS teaching was a sense of job security since nobody else in the business education department wanted to teach these challenging (CS) courses.

[Becky]: "Why I'm interested in [teaching CS]? Overall, it's challenging. It's something new for me. I think it's job security. I really do. I mean, especially for AP. I think they need you to some extent, if that makes sense. Not everybody is willing to teach it. Any of the Business teachers here should teach it. Now, it's Computing in the Modern World, there are two of us teaching. So, she's learned a little bit about things. But nobody really wants it. "

Although she was not happy with the reality that CS courses were currently offered as electives, she was also conservative about the possibility of putting CS in

another academic area like Math. She was worried that such change might put her job security in threat in spite of the benefits for students.

> *[Becky]: "We're considered electives. That's okay… I would like to keep it within the Business [department] only, because I am in Business [department]. But if they put it in the Math Department, then the Math teacher would have to teach it, and I don't want to become certified in Math. So, that's what scares me there…. CS is elective now, so they (students) don't take it seriously. So, I think by putting it in the Math Department, it would be great. I think it would be definitely more improved. You would proceed as a really important class if it was part of academics. But then I would be afraid for my job."*

Even if she had over eight years' experience in teaching CS and she also held a background in CIS, she did not feel confident and was struggling with how to teaching CS well. She perceived CS was hard to teach since it is changing and it is hard to explain abstract concepts.

> *[Becky]: "I struggle with giving everyone the material and being able to explain it to everyone… I struggle with how to be creative with the programming. I have a problem with trying to make the programs have meaning to them... It is hard to teach. It's hard knowing how to teach it, how to give it to them… It's hard to explain… I would have to definitely update my skills probably. I would have to do something because I don't know if it's old age or what. When I look at kid's codes, they think I should know it… They think that I should know it as soon as I look at it. For the*

longest time I thought I should, but I don't have to. I have to study it just like they do. So, I would like some training."

As she saw CS was hard to teach, she felt the need of learning more about CS and CS teaching.

[Becky]: "So, I would like some training. Every year, I would like to stay in the training. I try to go to [ICE] workshops every summer."

- **Bob: Computer teacher**

Bob saw himself mainly as a computer teacher even though he also taught many other courses. Meanwhile, he also reported that he used to being seen as an engineering (technology) teacher by the county since he was first certificated in Technology Education. Now, other teachers saw him a "computer person" due to his background in CIS.

[Bob]: "I am a high school teacher. I teach everything they ask me to, Computer Science. I teach Engineering, but my major focus is the programming and Computer Science courses… If asked, I say I'm a Computer teacher… Even though I've taught Engineering for awhile, I'll say that I'm a Computer teacher…

The county groups teachers by their disciplines. When I first started teaching, they grouped me with the Engineering teachers. So, I'll go out to the Engineering meetings with the Engineering teachers… When you get to be known as a computer person, people assume that you know everything about computers, and I don't. So, if they hear, "Oh, you graduated in Computer Information Systems? Oh! Well, then you must

know how to do this, this, and this"… [For example], I'm not a graphic designer. I don't know everything about Adobe… I don't know any of that."

He reported that he was most interested in teaching CS other than the Engineering courses, which his first certificate allowed him to teach. He explained that he pursued a Technology Education certificate when he decided to be a CS teacher because he thought that would enable him to teach CS courses. Afterwards, he got a Business Education certificate after he figured out that was the *right* certificate for CS teachers.

Bob recognized CS as "problem-solving using computers". He saw CS as an individual pathway and equally valuable as other pathways under the CTAE department. He further pointed out that he would like to teach all CS if possible and he was eager to learn more about theoretical foundation for CS and more teaching techniques to become a better CS teacher. Therefore, he was pursuing a Math Education degree.

[Bob]: "I'm working on getting a Masters in Math Education. Honestly, I'm curious about mathematics, and I see mathematics as a foundation that everything else is built on, including Computer Science. Like the concepts and theories that math philosophers and theorists hold, we use all the time in Computer Science… Right now I'm studying Math because I want to get some theoretical foundation to add to my application foundation… I don't plan on teaching Math classes… I would like to teach CS all day."

He further reported that he learned teaching techniques from the Math Education program to apply to his CS teaching, even though he was not planning on teaching Math.

[Bob]: "[In this program, I learned] definitely some classroom management techniques… having procedures set, having goals in mind. Classroom management has been really, really big. Also, [I learned] methods of teaching. One of the things that I did a project on is discovery learning and what that is… I've actually applied that to a lot of my classes, especially my AP Computer Science and my Programming classes."

- **Alex: CS teacher**

Alex identified himself as a CS teacher. He taught computing courses under the Interactive Media Pathway, which consists of the four courses: Computing in the Modern World, Fundamentals of Web Design, Advanced Web Design, and Introduction to Animation in 3D. He claimed he taught Computer Science, although he was not teaching and his department did not offer the CS courses under the Computing Pathway. When asked why he offered the Interactive Media Pathway courses, he explained this choice as for accommodating broader student interest He believed that programming was hard and only attracted a small group of students, while interactive media could make students interested in computer by doing things in relevant areas.

[Alex]: "We try to offer the courses that are in the Pathways that will be of most interest… Some people are very interested in Programming. But most people are interested in computers because they're tools that will allow them to do things in areas that they're interested in. Our students here at this school are very visual learners. We have very many artists. Between the visual learning and the art, the idea of Interactive Media is very appealing to them. They might become programmers at some point,

but we only have a very few who love the computer just because of the computer. So, they're much more interested in developing web pages, and producing videos and animations, and graphic design, and those kinds of things. So, that's why I picked the Interactive Media. I think the programming would be very hard. I think it would be very unpopular here at the school."

Similarly, he was not satisfied with the current CS curriculum arrangement. First, he complained that putting CS under Business could limit the scope of CS and which might lead to the lost of student interest. And more courses should be offered under CS like Computer Aided Design and Digital Media Production.

[Alex]: "I definitely see Computer Science underneath Career Technology Education, but I don't really understand why it's under Business… I think it limits the Computer Science a little bit by being underneath Business. I think Computer Science is broader than Business Applications. You know, it's obviously used for an awful lot more in the world than just Business… So, I think they've kind of narrowed the Computer Science offerings down to less interesting things… So, if we take away too many of those things from the Computer Science curriculum, we're going to find our numbers dropping. Like if I just have to go after the pure programmers, the ones who are interested in programming becomes a very small number of students."

Furthermore, he complained that the CiMW as the first CS course drove away student interest by focusing on computers.

[Alex]: "I don't like having the Computing in the Modern World in that Pathway as the first course, because I believe that first you get people interested in things. Then they start digging in and want to learn more. Computing in the Modern World is one of those courses where it's a turnoff. People don't like it. It's not fun. It's about the computer. You know, it's about the disk drives and the displays, and the network, and the databases, and systems management, and all that stuff… Computing in the Modern World is there to supposedly establish a foundation so that when you're starting to teach them the other classes, they can do a better job. But I think it drives away interest, frankly."

After complaining the current CS curriculum and its affiliation with Business Education, he further expressed a sense of crisis as a CS teacher, which drove him to preparing a math education certificate for job security.

[Alex]: "High schools are much more interested in the core subjects - the Math, English, Science, and Social Studies, which have the Georgia High School Graduation test. They're much more interested in those than anything else in the whole world. So, they're much more interested in those than the Career Technology Education classes. So, I just took the Math test because I wanted to make sure that I could find a job in a school that I might want to go to. So, I just took the Math test just for that. That's the only reason I took that."

3.5.2 Mixed: CS and X teacher

Three teachers identified themselves as teachers in both CS and another subject. Cindy was a Math and CS teacher. John saw himself as both a CS and Math teacher. Pat was a Business teacher as well as a CS teacher.

- **Cindy: Math teacher teaching CS**

Cindy saw herself as a Math teacher who taught CS. She had a Math background and was certificated in Math Education. She believed that she was still a Math teacher although she taught only one Math course along with three CS courses because she saw CS as part of Math.

> *[Cindy]: "I am a Math certified teacher, so I am a Math teacher who teaches Computer Science. I really think that Computer Science is a Math-type course. I mean, it's like Applied Math. You're applying what you know in Math to that. We do a lot of problem-solving in there. We do a lot with algorithms, a lot with logic. I mean, how can you not call that a Math class? I mean, it really is, in my opinion, a Math class."*

Considering CS as part of Math, she used lots of Math problems as examples to be solved by programming, e.g., asking the students to turn the quadratic formula or the distance formula into a Java statement, or asking them to take a 2D matrix and figure out a magic square by writing a code. She also saw a CS class different from a Math class since she believed that CS required more interaction, trying and exploration and she could be more creative in a CS class than in the Math class.

> *[Cindy]: "I think I teach in that [CS] room very differently. There's a lot more individual time for them. They are expected to do a lot more on their*

own. So, that's very different from a Math class where you're giving them new information every day and you're expecting them to go home and do practice… We do a lot more as a group in [CS] class. It's not me lecturing. We do a lot in Dr. Java in the interaction pane, kind of more exploration to that... My teaching style is very different. When I teach my Math classes, I'm teaching along with a group of five other people who teach that class, and you all need to be fairly similar. But being the only teacher that teaches it lends me a lot of freedom."

As the only teacher teaching CS courses in her school, Cindy wanted to get connected with other CS teachers, but did not feel that there were colleagues that matched with her styles/mindsets and can collaborate with.

[Cindy]: "I don't have many colleagues in the county that I can turn to… I don't feel like there are… I don't feel like I have a lot of connections in [the local] county or with a lot of people… I've sat and I've talked to people… They all have their own way of wanting to do things [in CS], which is okay, but you know, we have a lot of people who are Business teachers with no idea what they're doing with this class. I'm hoping to meet more people that I can collaborate with and more that are more like-minded to my style of teaching so that I can get more ideas that way."

But, still she wanted to stay in Math for job security. She felt more comfortable in teaching Math while CS was more challenging.

[Cindy]: "I started just teaching the Computer classes, but I wanted to teach Math classes. That was what my degree was in. But, I'm glad [I

taught CS] because I really enjoy it… I have familiarity with [math]… I want to stay in the Math area as well. I don't want to go all the way over to that other side, because I was trained to be a Math teacher."

- **John: CS and Math teacher and more passionate about CS**

John called himself Math and CS teacher, but he explicitly expressed that he was more passionate about teaching CS than Math. He got a Math Education Certificate as the route to teach CS. He was seen as a Math teacher by his students since he worked in the Math department and his classroom was on the Math hall.

[John]: "I would introduce myself as a Computer Science and Math teacher at the secondary school level… I'm in this strange role where I am bound as the Math teacher. It's something I do. I identify as being a Math teacher, but I would much rather teach Computer Science classes and I'd much rather those be the classes that I teach… The way that I work, my classroom is on the Math hall. I attend all the Math meetings, and my students sometimes will meet in my room in the Math hall, if you asked the students, they would probably think it's maybe even a Math course, because I'm known as a Math teacher, and I teach the class."

He further expressed that he enjoyed teaching CS and that was always his passion. He studied Math as well to help himself better understand CS.

[John]: "I think I'm definitely more passionate about teaching Computer Science. I enjoy teaching Computer Science more, but the current state of Computer Science education in Georgia, and especially at the school that I teach in, is such that I teach two Math classes each day and one

Computer Science class each day... But if I could ultimately choose what I taught, I would definitely prefer to teach all Computer Science. In school, that was my first choice as a major. I ended up adding a Math degree just so I would be a little bit more likely to understand some of the complex topics in Computer Science."

He saw the values of CS in high Schools. Furthermore, he felt CS was more relevant and motivating, compared with Math. He also believed CS should be a bigger part of education.

[John]: "I think so many of the Computer Science topics make so much more sense and are so much more relevant to students than some of the more obscure things that we require every student to learn in Math. I just think we've got to do something to make Computer Science a bigger part of education, because technology is just pervasive today in our way of life… I just think about how so many problems are solved with computers across so many different occupations that our students might have. It's just helpful for them to understand how it works. I also think it's a great way to develop problem-solving skills, which is certainly something all students need before they're thrown into the real world."

After expressing his beliefs in the importance of CS and his own passion in teaching CS, John explicitly said that he would like to learn more about CS education to be a better teacher and he himself was working on growing the CS program at his school.

[John]: "I would love to be in a place where I taught all Computer Science. I'm hoping that one day that will happen. I'm trying to grow the

Computer Science Program at the school that I currently teach. I'm also, planning on continuing into a doctoral program later on, possibly... I would love to reach Computer Science and I'd love to study more about Computer Science Education… I still feel like I've got a lot to learn about teaching… I feel like the past three years, I've learned so much. I feel like it might help me to continue as a teacher to learn a little bit more about what I would like to study, if that's a path that I want to take, because I could also see myself being really happy continuing to teach."

However, he felt that he was a better Math teacher than a CS teacher due to the lack of support from peer CS teachers. He was eager to have a community of CS teachers, which could help him go through with CS teaching issues.

[John]: "The frustrating thing is that two years before, I made really slow progress because I wasn't even really aware of BlueJ. It would have been such an easy problem to solve if I would have been in a community of Computer Science teachers, because we would have talked about these things… Even though I feel like I know Computer Science better than Math and I'm more passionate about it, I still think I'm a better Math teacher, just because I've had so much support. Whenever I have problems, I can talk with the people that I work with, most of who have taught for many years in Math. If we're eating lunch, every day, I'm eating with Math teachers. So, we can talk about our problems. With Computer Science, I've got nobody to talk to. I've learned so much about how to teach Math just in lunch conversations with other Math teachers.

That's something that you don't get unless you had a really large school that has multiple Computer Science teachers."

- **Pat: CS and Marketing teacher**

Pat saw herself as a CS and Marketing teacher since these were the two subjects she was teaching. She was working on building these two programs in her school, while currently she was in a special situation with courses in these two subjects combined together.

[Pat]: "They hired me to do Computer Science and to try to build the program back up. Also, I'm Marketing Education certified. So, that program also got kind of run into the ground. So, unfortunately right now, I'm kind of doing both. I have 4 sections of Computing in the Modern World, 1 Section of Beginning Programming in a class combined with a section of Intermediate Programming, and 1 section of Marketing Principles. My plans for next semester look to include a class where I might see Beginning Programming, Intermediate Programming, and AP CS in one classroom as one time, Marketing Principles and Sales and Promotion in one class at one time, and Computing in the Modern World."

As the only CS teacher and this was her first year of teaching AP CS, she felt challenging in both learning the programming language (Java) and putting materials together. She felt that she was isolated and would like to learn specific content and techniques to teach CS. She also wanted to get connected with other educators who cared about teaching CS.

[Pat]: "I just feel like as one Computer Science teacher in a high school, you're on an island.... I would like to get a solid foundation on the course(s), the content, and get ideas on approaches to teach the various concepts. I would also like to get networked in with other educators and maybe industry personnel that want to help. I would also like to be part of a bigger picture that puts together the lesson plans, toolkits, etc. that every county and school can use to teach."

She also complained that putting some Business teachers who did not want to teach CS into this CS education community hurt the program.

[Pat]: "One of the biggest problems I see is that Computer Science has been lumped in with Business Education and many of these teachers want nothing to do with Computer Science, consider it too hard to learn, don't have the background to be effective in it, and want to go back to keyboarding and computer applications. They hurt the program because they "have" to teach CiMW… They don't ever want to be technical… If a teacher wants to learn it and teach it they can, but so many don't and the lumping into Business education has hurt the progress in my opinion."

Still, she would like to continue to teach CS for a sense of job security.

[Pat]: "It's extremely difficult to hire Computer Science teachers. So, that's probably where I'll end up staying and where I'd like to stay probably."

3.5.3 Business teacher

The other two teachers identified themselves as Business teachers: May and Rose.

- **May: Business Education teacher**

May called herself Business teacher, even if she mainly taught CS courses. Meanwhile, since she taught classes on the computer, other teachers in her school saw her as the computer teacher.

> *[May]: "I introduce myself as a Business Education teacher. Even though most of the courses I teach are Computer Science, for some reason, I always say Business Ed…They call me the Computer teacher, believe it or not because a lot of the teachers come to me for technical support. Especially, like my lab, my computer lab. So, every now and then, I'll go in there and write on the white board, 'If you need help, email the technical support.' You know, I'm not saying I don't want to help them, but I get overwhelmed ... They call me the Computer teacher probably more often because they know that everything I'm teaching is on the computers and it's technology."*

She believed that Computing/computer is important to learn since it's ubiquitous in students' future careers. She tried to help her students understand this point through her class.

> *[May]: "The values to me for the computing is any job that you have that a student gets, anyone, you've got to know how to use a computer. They're everywhere. They're in cars. Everything has a computer in it. So, there's value in it for everyone; even the people who say, 'Oh, I don't like computers.' So, there's value in using computers for everyone. I try to help them understand and help them see that."*

Although she believed *computing* was important for every student, she is willing to teach any *computing* courses. However, she struggled to *differentiate* "computing" and "CS". She first thought only the AP CS course counted as a CS course, while other course like CiMW and Beginning Programming were not CS but computing courses. During the interview, she then *corrected* herself that CS was about programming. Overall, she believed that computing as being able to operate the computer, while CS as advanced programming and was only for those smart students.

> *[May]: "I think, computer science is more for really, really smart people. I'm not saying I'm smart, but I'm thinking that if I have to go take this Computer Science degree, that it's going to be really hard, because it's going to ask a lot of programming questions, syntax questions. I think computer science is a much higher level…When I say computing, I think of computing as being able to operate the computer, being able to go in and type a Word document, being able to use the Internet, being able to create a document, maybe create a PowerPoint, just navigate around a computer… I believe that most students can successfully take and complete Computing in the Modern World, but it takes a little higher level of intelligence to complete the Introduction to Programming and the AP Computer Science."*

When asked about any community of CS teachers she attended and where she usually looked for resources, May reported that although she was isolated as the only one who taught CS course, she felt confident in teaching those courses. First, she felt herself got more confident in the process of teaching every year. Second, she felt the general

resources she could access from the CTAE department in her local county and the state was sufficient for her.

> *[May]: "Here in [the local] county, we're very fortunate to have a program where when new teachers come in, we have a shell now where all of the files are uploaded, all the projects, everything. They give us a pacing calendar… They just set up a schedule for you... So, we come with a bunch of files. This is done every summer… But it's not like I have to sit here and design a whole course by myself. It's pretty much done and I just have to lay it out on what I'm going to teach when and how that's done. So, the county, the district, pretty much supports our Technical Ed Department… The State of Georgia also sends us a disk. This year was the first year because we have new pathways. It had so many projects on it that they've done at the State level for each course, and they're always sending us links to websites. See, you're not alone teaching the courses, even though I'm the only one at this school teaching it. Also, if I have a question, we all have Program Specialists in our district. So, that's who I will go to with my question."*

- **Rose: Business Education teacher**

Rose, in her third year of teaching, was the newest teacher among the ten participants. She saw herself currently a Business Education teacher since she only taught the very first CS course (CiMW).

[Rose]: "I consider myself a Business Education teacher. At our school, since we're so small, I'm the only Business Education teacher… I don't consider myself a Technology teacher. I consider myself a Business Ed teacher. I don't necessarily consider myself a Computer Science teacher just because we only teach Computing in the Modern World this year. Next year, if we were to offer Beginning Programming, which I'm hoping we will but can't guarantee it, I would probably consider myself a Computer Science teacher. I don't know. I don't really consider Computing in the Modern World enough to give me the title of Computer Science."

She further expressed that she liked teaching computer software and was also willing to teach more CS courses if workload allowed.

[Rose]: "I love computers! I like teaching Computer Software. I like teaching them all the Adobe software. I like teaching them how computers work… I would love to teach the advanced classes. I would love to teach Advanced Web Design. I would love to teach Intro to Programming. I would love to teach those advanced classes. But because there is only one of me at the school, I'm not going to get that opportunity until they hire another teacher."

Meanwhile, Rose was comfortable with no programming course was offered for students interested in CS because she thought that other Business courses can meet students' need instead.

[Rose]: "I think that most of our students, who have been interested in Computer Science and have asked about it, although we're not teaching it, truly do have a desire to learn Computer Science. They were really disappointed that we're not

offering it… They truly want it, and I think they've settled for Business Ed classes. I think they might try to be in Programming than in the other Business Ed classes. But I think as an overall department, I think they flow well together, because I think there is some interrelated stuff. So, I think that they mesh well. Some students who want to go into like Programming or whatever might want to own their own business. So, Business Essentials would be great for them, because it teaches them entrepreneurship and the skills behind the scenes that they may need to start their own business."

As the only Business teacher in her school, she felt the need to get connected with other Business teachers. She felt the need of keeping herself updated, and was willing to create a site for Business teachers. Meanwhile, she believed that she knew enough to teach the CiMW course, and only teaching programming or AP CS might require learning due to her lack of knowledge in computer programming.

[Rose]: "…You have to learn! You have to stay up-to-date!... I just don't think Computing in the Modern World is that difficult to need that much collaboration. I mean, I think the class is pretty straightforward. I see where in AP Computer Science, you would need a lot of inspiration to continue with projects and all that and need help, because I thought I was teaching it this year. I was a little bit stressed because I didn't know an ounce of computer programming. How do you teach programming if you don't know it? It's like teaching Spanish with never having learned it."

3.5.4 Summary of self-identity by teachers

The above sections presented how the participants self-identified themselves as teachers in different subjects: Math, Business and CS. Overall, these teachers all taught more or less some form of CS, but not all of them identified themselves as a CS teacher. Moreover, they were different in terms of their confidence and commitment to CS teaching. A few of them either were not committed to CS teaching or did not feel confident in their own teaching. Some of these teachers also held biased opinions about the subject they were teaching and who they should teach.

Meanwhile, all of these teachers were isolated. They all felt the lack of peers and community. Most of them except one Business teacher were looking for opportunities for continual learning and connecting with other teachers teaching CS courses.

3.6 Influencing Factors

The above section presents the teachers' perceptions about themselves being what kind of teachers. This section summarizes how teachers explained for their own perceptions as CS teacher or CS in another subject. Overall, four different kinds of factors were identified that contributed to these teachers' identity related to their teaching in CS (with at least two teachers reported similarly):

- teachers' educational background and certification,
- CS curriculum and department hierarchy,
- availability of CS teacher community,
- teachers' perceptions about the field of CS.

3.6.1 Educational background and certification

First of all, these teachers relied on their own educational background to identify themselves as teachers in a specific subject. For example, Bob claimed himself as primarily a CS teacher due to his computing background.

> *[Bob]:"…Mainly because my background is in computers. My degree is Information Systems, and because as I said, that's my focus… But what I feel like my specialty is and what I want to put most of my interest and my focus, and my attention and time on is the computer courses, and given the opportunity, I'd like to focus on that."*

Similarly, John also preferred to teach CS since that was his major. In contrast, May saw herself as a Business Education teacher since her major was in not in CS but in Business Education.

> *[May]: "Well, I identify myself more as Business Ed. I teach Accounting, also. I've taught Computer Applications. So, really my degree is not in Computer Science. It's in Business. So, that's just my identity."*

Another Business teacher, Rose, also made similar claim as Mary. Furthermore, she also recognized that she would need to learn a lot to be able to teach more advanced CS courses like AP CS due to her lack of background in CS.

> *[Rose]: "I was a little bit stressed because I didn't know an ounce of computer programming. How do you teach programming if you don't know it? It's like teaching Spanish with never having learned it."*

Beyond self-identification, teachers' personal educational background also influenced other aspects of their identity (e.g., their confidence in teaching) and likely

their teaching practices as well. For example, as presented in Section 3.5.2, Cindy felt more comfortable in teaching Math and could "get a good handle on Math" since she was more familiar with Math. She also saw CS as part of Math. In her CS classes, she used lots of Math problems as examples to be solved by programming. Moreover, she would like to stay in teaching Math even if she enjoyed in teaching CS.

Similarly to teachers' educational background, they used the certificate(s) as one criteria to determine their own teacher identity. For example, May and Rose believed that they were Business Education teacher since that was what they were certified for, as May said:

> *[May]: "I introduce myself as a Business Education teacher. Even though most of the courses I teach are Computer Science, for some reason, I always say Business Education."*

Meanwhile, Cindy claimed herself as a Math teacher even if she taught more CS courses than Math.

> *[Cindy]:"I am a Math certified teacher, so I am a Math teacher who teaches Computer Science."*

Furthermore, Certificates also determine the path teachers came into CS teaching, which also influenced how other entities (e.g., the local county and local school) identified the teacher in related subjects. For example, Bob was seen as an Engineering teacher due to his first certificate in Technology Education, which determined the courses assigned to him and his professional development requirements. In fact, Bob was always interested in teaching CS. He was confused with which certificate would allow him to teach CS courses and thus experienced a devious path to CS teaching.

[Bob]:"I had my Technology Education certification first… I originally thought Technology Education would encompass the Computer classes. It wasn't until I got into the school system that I realized or I found out that Computer Science was under Business. … [I then did the Business Education certificate] because I wanted to teach the Computer Science classes. I didn't want any justification for them not allowing me to teach them."

Similar to Bob, since there was no specific certificate for CS teaching, John got a Math Education certificate as the route to teaching CS. He had started teaching Math before he was able to teach CS.

3.6.2 CS curriculum and department hierarchy

Participants also reported that CS curriculum and department hierarchy influenced their identity related to CS teaching. Here, CS curriculum and department hierarchy refer to what courses are offered under which part of the secondary curriculum and thereby under which department/academic unit. In Georgia, CS courses were offered under the same unit (Business and CS program under the CTAE department). These courses were electives. Such situation prevented students, administrators as well as teachers seeing the values of these courses. Meanwhile, by putting CS under Business, some Business teachers not interested in teaching these technical courses had to teach these courses. These teachers likely did not value what they were teaching or were not motivated to teach these courses. As we will discuss in the next section, As Pat complained earlier (see Section 3.5.2), this situation could also hurt the sense of community of those isolated but more motivated CS teachers.

Another teacher, Alex, further complained the current CS curriculum offered in his school as being excluded from the core curriculum and having CiMW first might lead to the lost of student interest. He further expressed a sense of crisis as a CS teacher, which drove him to preparing a Math Education certificate for job security (see Section 3.5.1).

3.6.3 Availability of CS teacher community

As we can see from section 3.5, most of these teachers expressed their needs of learning to be a better teacher for teaching CS, including all the four CS teacher and the three mixed subject teachers listed in Section 3.5. Most of these teachers were the only CS teacher in their local schools. To some extent, these teachers were isolated from their peer CS teachers. The lack of community for CS teachers did not only prevent some learning opportunities among those peer teachers, it also hurt these teachers' feeling about themselves. These teachers felt that they did not have peers or colleague as themselves. As presented in Section 3.5.2, Pat was complaining about those teachers who did not care about CS hurt the whole community of CS teachers. Cindy was looking for teachers with similar mindsets for collaboration, those who did not just see CS as computer applications and did not teach programming like teaching applications.

In addition to the sense of belonging/affiliation, lack of community/peers also influenced other aspects of teacher identity. As presented before, John felt himself was a better Math teacher than a CS teacher due to the lack of support from peer CS teachers. He was eager to have a community of CS teachers, which could help him go through with CS teaching.

3.6.4 Perceptions of the subject (CS)

The participants also held different perceptions about the field of CS and CS education. These perceptions influenced specific aspects of their teacher identity in CS teaching, such as their beliefs in the values of CS, their confidence in teaching CS, the need for learning and CS teacher communities.

First, they had different definitions about computing and CS. Most teachers saw the values of learning CS and broadly defined CS or computing as problem-solving using computers. However, the two Business teachers had some confusion about the meaning of CS and computing. Both of them saw learning computing as learning about operating computers. So, they recognized the values of learning "computing" for every student. Meanwhile, they narrowly defined CS as being only about programming and was only for smart students. Thus, CS belonged to higher-level skills and was only for those smart students. Therefore, their understanding of CS and computing determined their goals of teaching those courses. For example, May believed that *computer science "was more for really, really smart people."*

Secondly, whether being able to see the changing nature of the CS field also influenced other perceptions of the teachers, such as the challenges of teaching, the need of continual learning as well as a community peer CS teachers. For example, Becky perceived that CS was hard to teach due to its evolving of languages and tools. As presented in Section 3.5.1, she clearly saw the need of updating her own knowledge and skills. Similarly, Cindy and Ryan understood that CS was an evolving and broad field, its changing nature made changing answers about best practices and they needed to learning with peer teachers.

[Cindy]: "Well, the best ways, because of change, I very rarely refer to something as the best. It just feels wrong. As soon as you say something is the best, something else comes along to change it… I don't think I have the answer to your question. But it's an always evolving journey and it's different every year."

[Ryan]: "[CS is evolving]… which is probably why it's so important to have a group of peers that you have collaboration with that's not just a muse group on the Internet. That you actually have some meetings with from time-to-time or that you co-teach a unit at some school, or have a special program in the afternoons."

3.6.5 Summary and discussion: A tentative theory of CS teacher identity formation

- **The four main factors together**

The above section presents the four kinds of factors that mainly contribute to these teachers' perceptions about their own teacher identity related to CS teaching: teachers' educational background and certification, CS curriculum and department hierarchy, availability of CS teacher community, and teachers' perceptions about the field of CS. These four aspects are not individual factors and can interact with each other in influencing CS teacher identity. Figure 2 summarizes how these four factors work together in influencing CS teacher, which offers a tentative theory of CS teacher identity formation.

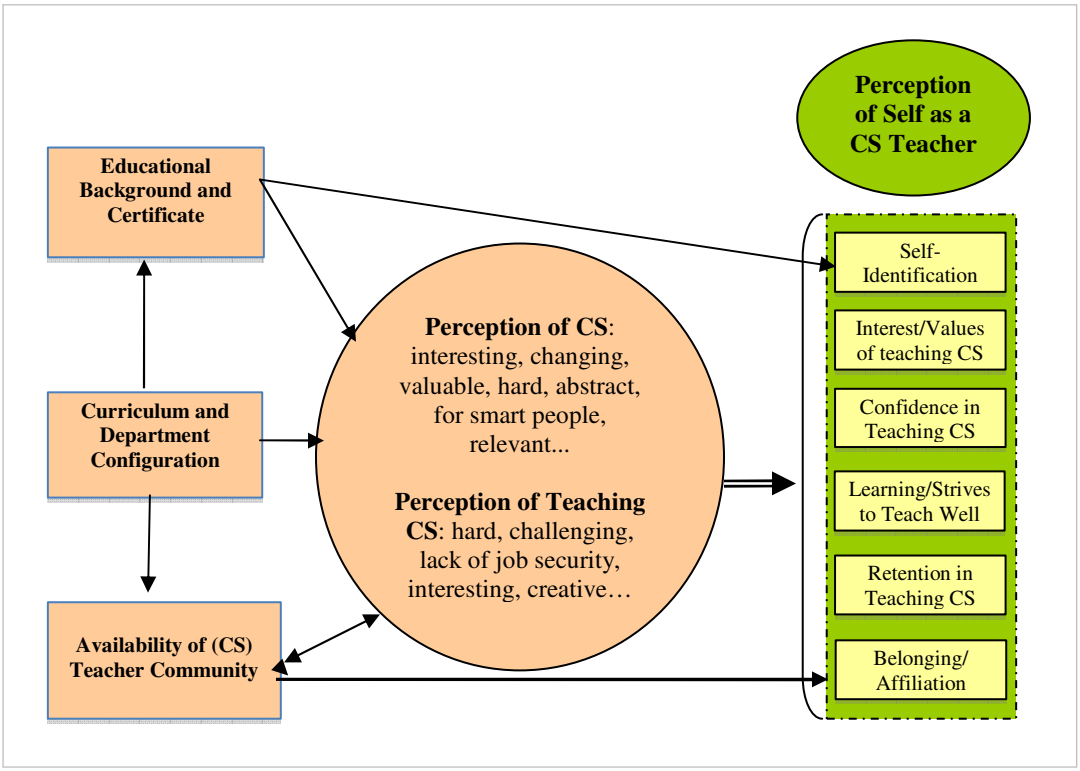


Figure 2: Main Influencing Factors for CS Teacher Identity Formation

First, it is natural for a teacher to pursue a certificate in his/her own major. We can see an overall match between these teachers' educational background and the certificate (s) they held. For example, Cindy with Math background had the Math Education certificate. Pat got a Business Education certificate while having a major in Business. These varied backgrounds and certificates determine how teachers self-identify themselves as a teacher in which specific domain.

Second, the structural aspect of secondary CS education determines the academic nature of CS (curriculum). In Georgia, CS is offered under Business within the CTAE curriculum. Teachers usually need a Business Education certificate to teach CS. Such an administrative context can cause other issues for CS education. First, teachers holding a

certificate in another subject but without CS background can be assigned to teach CS. Second, CS courses as electives can hurt the value of CS and lose student interest. This can then lead to fewer students, therefore fewer CS courses offered, and fewer CS teachers needed. Such ripple effect could cause the isolation of CS teachers.

Third, teachers' perceptions about CS influence their sense of the need for learning and what kind of community they want to join. With different understandings about things like what is CS, who should learn CS, what are the goals of CS courses, they can form different opinions about themselves and who count as their peers.

Fourth, the first three factors (background and certificate, CS curriculum and department hierarchy, lack of CS teacher community) together can cause a lack of expertise in CS and CS teaching among these teachers, and determines their perceptions about CS and CS teaching, e.g., what is CS, who should learn CS and what are the best practices for teaching CS, etc. Furthermore, these perceptions about CS and CS teaching can influence how the teachers feel about themselves as well. For example, a teacher who has a narrow view of CS might see CS as computer applications and thereby feel satisfied with teaching CS as applications. Such a teacher might not see the need of learning as well.

It is obvious that the first two factors are more structural problems and hard to change under the current educational system. Therefore, it can be one way to offer support for our current CS teachers and influence their own sense of identity by creating a community of local CS teachers where they can learn and support each other and change their perceptions of CS, CS teaching and themselves as a (CS) teacher. Study 2

attempts to understand how the participation in a local community of CS teachers influences their sense of identity.

- **Other potential factors**

In addition to the main four factors, results from this study also suggest two potential aspects that influence CS teacher identity: teachers' personal interest/passion in CS, and the social and physical configuration of their teaching environment. These two factors were only reported by one teacher (John). In particular, John was very passionate about CS, which drove himself to purse CS teaching. His passion in CS motivated him to recruit more students so that he would be able to teach all CS courses. He was eager to share his own passion in CS with his students and other teachers. He was also seeking CS teacher communities and other learning opportunities to improve his CS teaching. This finding is consistent with the findings from a earlier study of factors that influence CS teacher change (Ni, 2009). In that study, I found that teachers' personal interest/excitement in the content was a major (positive) factor that drove effective adoption of curriculum innovations.

Meanwhile, the working environment (especially its physical and social configurations) influenced his sense of identity as (not) a CS teacher. He mentioned that he was identified as a Math teacher by the students as he was located in the Math department and students usually saw him in the Math hall. He was able to talk with Math teachers in the department very often through regular department meetings or just by having lunch together with other Math teachers. In contrast, he felt less confident in teaching CS without similar environment for CS teachers.

- **An inherent challenge for CS teachers: the evolving nature of the field**

Reflecting on these four factors, I see one unique and inherent challenge for CS teachers: the fact of the relative newness and evolving nature of the computing field. The field of CS is evolving, with rapid changes in many aspects, such as the overall paradigm of programming (e.g., from procedural to object oriented), updating in programming languages and tools. This changing nature of CS makes teachers feel that CS is hard to teach and requires continual learning. Thus, teachers feel challenged in teaching CS and not confident or even not willing to make commitment in teaching such a hard subject. Meanwhile, since CS is a relatively new in secondary education, researchers and administrators are working on understanding the fundamental problems in K-12 CS education. Those structural problems (e.g., the lack of CS certificate) can be temporary for CS teachers.

3.7 Summary of Chapter 3

This chapter presents findings from study 1, focusing on understanding what kind of identity CS teachers hold and what contributes to their perceptions as (not) CS teachers. These findings offer examples of different self-identity and identity features from those teachers who see themselves as a CS teacher, as a Business teacher, or as a teacher in both CS and another subject. The identity information from this study serves as the initial status of the four teachers in study 2. The stories of why teachers see themselves as (not) a CS teacher also provide insights on in what ways the DCCE program can have influence on these participants' identity development.

CHAPTER IV DISCIPLINARY COMMONS FOR COMPUTING EDUCATORS

4.1 Design of the Second-year DCCE

The DCCE, in particular, starting from the second-year DCCE, is an intervention program designed and implemented to understand and support CS teachers' identity development. As stated in Chapter 1 and 2, I use teacher identity as a theoretical concept to understand some unique needs of preparing and supporting CS teacher Here, I summarize a few implications that identity theories together with some other related work offer for the design of DCCE:

- The process of becoming a CS teacher who values, is capable of and committed to teaching CS courses can be better understood and supported as we think of it as developing a professional identity.
- (Beginning) teachers may hold core identities that might need to align with the new identity being considered. Trying on a new identity may involve assuming risks, which suggests the need of providing safe and supportive contexts for this exercise.
- Although participation with a community of practice is essential, learning as professional identity development occurs in the interpretation, narration and thus recognition of that participation by self and others. Therefore, offering opportunities and supports for this ongoing recognition activity is critical.

- While reflection is a powerful aspect of teacher learning and identity development, simply providing opportunities for teachers to reflect is insufficient. We need to provide facilitation to promote productive reflection.

Turning the above implications into the design of DCCE, DCCE attempts to support CS teachers' learning and identity development in a variety of ways:

- DCCE is dedicated to building a vibrant community of computing educators. Bring teachers teaching a common course together offers a common ground for building a supportive community.
- DCCE offers ways to access resources of exemplary teaching and perspectives of peer CS teachers through peer review and peer observation.
- DCCE offers opportunities for teachers to narrate, question, explain and revise their own beliefs and theories about teaching CS through creating (self-reflecting on) and peer reviewing their own course portfolios.

Summarized in Figure 3, I proposed that the DCCE program could support CS teacher identity development (the right part of Figure 3) by promoting teacher reflection and community building (the left part of Figure 3). Study 2 investigated in what ways DCCE influenced participating teacher's sense of identity as CS teachers.

The next section introduces the specific activities and meeting agendas designed and implemented to achieve these potential ways of supporting CS teacher identity development.

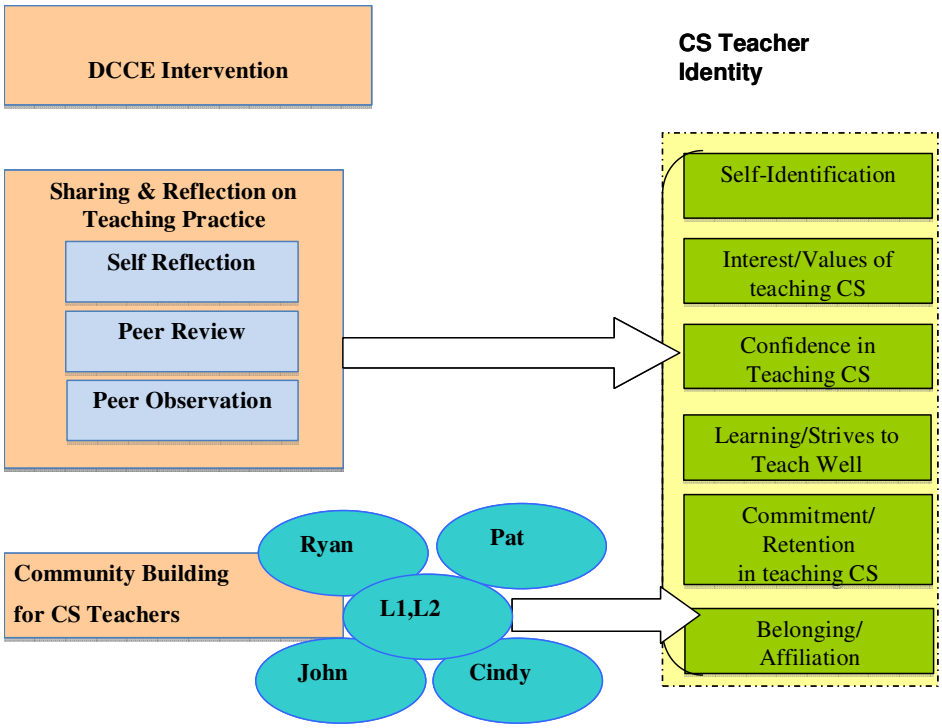


Figure 3: Design Rationales of the Second-year DCCE[8]

4.2 DCCE Activities

As introduced in Chapter II, the second-year DCCE program adopted the main agendas from the Disciplinary Commons, including its three mechanisms for sharing teaching practices among college computing faculty: course portfolio creation, peer review and peer observation (Ni, Guzdial, Tew, Morrison, & Galanos, 2011). In particular, I extended this model to include high school CS teachers and college computing faculty teaching introductory programming courses.

The second-year DCCE teacher cohort had four HS AP CS teachers and another four undergraduate computing faculty who were teaching introductory programming

[8] All the teacher names mentioned in this document are pseudonyms. Cindy, John, Ryan and Pat were the four high school CS teachers. L1 and L2 are the two teacher leaders in this DCCE teacher cohort.

courses within the participating year. These eight participants completed this one-year program and came back to meet six months later. These teachers were recruited through emails to department chairs of computing units in the University System of Georgia (USG), to AP CS teachers in the Georgia, and to contacts through "Georgia Computes!" workshops. Appendix C.1 lists the invitation letter. This letter introduced the overall goals of DCCE. It also included the potential benefits of participation as well as what the participants were expected to commit to in this program. Participation in DCCE was voluntary and free. Travel and meeting costs were covered by an NSF grant. HS teachers were also paid with a small stipend of $500 for completing the whole program.

Originally, twelve teachers submitted applications to attend this cohort and we invited all of them. However, four (two high school and two USG) teachers dropped out within the first two meetings. They reported two main reasons for their dropout from this program: one university faculty was more interested in workshops for introducing and developing materials than what the DCCE focused on. The other three teachers felt they could not meet the time and effort commitment required by the DCCE program. They would prefer professional development with a lighter working load. Therefore, only eight teachers stayed throughout the program. In addition, DCCE invited two teachers, including one high school teacher and one USG computing faculty from the first cohort, to act as peer-leaders. The peer-leaders led meeting discussions and participated in planning calls with me before each meeting.

Table 6: Meeting Plan for Second-year DCCE

Dates	Topics
Oct 24, 2009 10am-4pm	**Building the Commons**: who are you; how did you come to be a teacher? **Project overview** **Institutional Context**
Nov 14 9am-1pm	**Course context:** How does your course fit in the pathway/degree program(s), student demographics, operating constraints
Dec 12 9am-1pm	**Course Content:** Course anatomy. What do you teach? What are the parts? What are the organizing principles?
Jan 16, 2010 9am-1pm	**Teaching Methods**: How do you teach, what methods? Getting the "how" to fit the "what" and "why". **Introducing Peer-observation**
Feb 20 9am-1pm	**Teaching Philosophy:** Why do you teach what you teach? Why do you teach how you teach? What tacit assumptions do your teaching choices embed, especially about how students think and learn?
Mar 6 9am-1pm	**Student Learning:** What does student work tell you? What are students learning and failing to learn? Do you ask students to undertake work that you value?
Apr 24 9am-1pm	**Assessment:** How do you grade? Making criteria explicit. Why do you grade the way that you do? Assessing what you value.
May 15 9am-1pm	**Course Delivery:** Debriefing the self and peer observations. What did you learn?
June12 10am-4pm	**Portfolio presentations**
Dec 11 10am-4pm	**Reunion:** Portfolio reflection and change narratives

Participants met monthly for ten meetings within the 2009-2010 academic year (see Table 6 for the meeting plan). Specific meeting agendas were participant-driven, while the major topics covered came from the overall structure of a course portfolio as other Disciplinary Commons projects have. As stated earlier, DCCE has a specific focus on reflection and community building for supporting identity development, which is not a particular focus of other Disciplinary Commons projects. The DCCE research team modified the curriculum based on participants' interest, such as slowing down some

sessions to meet participants' needs, adding new discussion topics (e.g., student recruitment, CS Ed Week[9]), creating new forms of sessions (e.g., walk the wall sessions). Detailed agendas can also be found on the DCCE website[10]. This site served as a main venue for the participants to share resources and have discussions after meetings.

Participants were given certain assignments to prepare for each meeting, which typically included reading relevant literature, creating and (or) revising a specific pieces of their course portfolio and reviewing two other participants' portfolio. In each meeting, participants worked on a specific topic of their course portfolio through a variety of activities (e.g., round-robin discussion, small-group discussions, walk the wall, presentations). Participants were also offered time to exchange review comments on each other's course portfolios pieces and other issues that they were interested in. Appendix B.1 includes the agenda of a specific meeting with its learning goals and activities.

4.2.1 Creating course portfolios

Creating a course portfolio for one specific CS course was a major activity in DCCE to drive teachers' reflection on their own teaching practice. Participants constructed this portfolio in increments. Each meeting focused on one topic in the portfolio (e.g., course content). Participants drafted each part of the portfolio individually, reviewed each other's writing and discussed in/outside meetings, and then revised it afterwards. Thus, they completed the whole course portfolio through several iterations.

---

[9] CSEd Week: http://www.csedweek.org.
[10] DCCE website: http://sites.google.com/site/dcce2009/meetings.

They then presented their completed course portfolio at the end of this year's DCCE program and shared it through the project website afterward.

- **Scaffolding course portfolio creation**

In the first meeting, the overall motivation, goals and mechanism of creating course portfolios were introduced and discussed by the teacher leaders and the participants. Each month, participants were assigned with some related readings that helped them to understand a particular topic. They received some structured guidelines for creating each portion of the portfolio from the teacher leaders. For example, for the topic of *course content*, teachers were suggested to prepare this portion of portfolio in the following way:

Artifact: *One or more documents that addresses your course content. This will likely include parts of your syllabus and perhaps other documents that describes such things as topics covered, order of topics, duration of each topic, language and textbook used, etc. This artifact should describe the basic course anatomy, the bones and sinews of the course. You might want to include some key homework or project descriptions. Also, please bring in the textbook you use for your course, and any other physical (or virtual) artifact that you think would be helpful to share and discuss in the meeting.*

Annotations*: Answer the "Why" question with respect to your main syllabus choices (e.g., "Why these topics?" "Why this order?" "Why this language?")*

Here, "Artifacts" are what teachers need to bring into a DCCE meeting to share and discuss with their peers (e.g., a syllabus of the course, a specific lesson plan, or an example of student work. "Annotations" are the prompts supporting their reflection by questioning themselves and then articulating the implied beliefs and theories about their

own teaching. Teachers wrote a first draft, and then this draft was reviewed by two peer teachers among a meeting (for the first few meetings) or by emails later on. After getting feedback, they had the second assignment to revise it and then post it on the access-protected DCCE website. They also had opportunities to re-visit it as a whole at the end of the program.

4.2.2 Peer review

Peer review offered a further opportunity for participating teachers' recognition activity. Through reviewing other teachers' portfolios and gaining feedback from others, teachers were able to see multiple perspectives on the teaching of a common course. They could compare, question and interpret others' as well as their own assumptions and theories about CS teaching. Meanwhile, the peer review process also had a potential to engage participants in this community. The review recycles had two reviewers for every portion of each teacher's course portfolio. The consequence of one teacher missed a meeting or failed to complete one portfolio writing assignment would influence her reviewers who would like to review her portfolio and those whose portfolios she was up to review. Such a review mechanism was adopted to improve the accountability of the whole group of participants.

Extensive support for this peer review activity was also provided for the participants by several means. First, the DCCE research team including the teacher leaders created a general review guideline with instructions on courtesy rules, what to focus on in the review process, and what kinds of review comments were recommended. The research team also provided detailed guidelines for reviewing specific portions of the course portfolio. Appendix B.2 is one example of guidelines for reviewing others' course

portfolios (the teaching context portion). Further, for the first several meetings, significant meeting time was offered for participants to review portfolios, exchange review comments and discuss questions and issues they had about the review process. Then, the review process started to fade back as their homework, while leaving more time for deeper discussions on some specific issues the participants were eager to explore.

4.2.3 Peer observation

Peer observation offered another opportunity for teachers to uncover one's own as well as others' perspectives and methods of teaching CS. Participants were paired with those who taught at the same level (high school teachers with high school teachers). Each teacher visited another teacher's classroom observing his/her teaching. Meanwhile, everyone was also observed by a different teacher teaching at the same level. Teachers completed the peer observations by the April meeting, when they were discussing the findings from the observations. Guidelines for conducting peer observation were also provided to teachers, offering instructions on what to prepare for the observation, what to focus on during the observation with an observation notes form to fill, and what to debrief afterward, for both observers and the observees. These guidelines were adopted from another Disciplinary Commons project and made available on the DCCE website (https://sites.google.com/site/dcce2009/peer-observation). Appendix B.3 lists the worksheet we created for teachers to take notes during their observation activity.

The main goal of peer observation for the participants was not for evaluating the quality of teaching, but for promoting reflection. To help teachers learn how to conduct meaningful reflection, teachers were asked to do a small reflection exercise focusing on one specific teaching unit they picked up before the peer observation started. The teacher

leaders created a reflection log to model how to do teaching reflection, as attached in Appendix B.4. Teachers brought their reflection logs back to the DCCE meeting to share with each other and receive feedback from the teacher leaders and their peers.

All the above activities work together to support CS teachers' identity development. Let's revisit the design ideas of the DCCE program for supporting CS teacher identity development. As stated in Chapter 1, current CS teachers are facing big challenges in building their own sense of identity as CS teachers. DCCE is aimed at offering opportunities for communication and building community among peer CS teacher as well as explicit reflection on their teaching practice to support their identity development. DCCE offers great opportunities for teachers to narrate, question, explain and revise their own beliefs and theories about teaching CS as well as who they are through creating and peer reviewing of course portfolios as well as peer observing others' teaching practice. Meanwhile, DCCE also encourages a sense of community for our CS teachers through bringing teachers teaching a common course together to engage in supportive, friendly community activities.

4.3 Use of Programmatic Evaluation

As introduced earlier, the DCCE project is dedicated to building a local community for computing educators. The programmatic evaluation looks at how well DCCE has achieved its goals in terms of promoting teacher reflection, community building and communication among computing educators.

First, feedback forms were administrated at the end of each meeting to gather formative data on the meeting quality. One example of the feedback form was attached in

Appendix D.1. Second, Pre- and post- DCCE surveys (attached in Appendix D.2 and Appendix D.3) were used to further evaluate the quality of participants' experiences in DCCE. Third, the DCCE social network analysis (SNA) form[11] (attached in Appendix D.4) was administrated to understand the partnerships formed among the participants as well as the strength and quality of those partnerships. The participants reported on their interactions with other cohort members before and after participating in the DCCE program.

I rely on this evaluation information for an overall understanding about the quality of DCCE activities. In particular, when examining how teachers' participation in DCCE influences their sense of identity as CS teachers (study 2), I used programmatic evaluation data about their participation experience to help me understand how satisfied the participants felt about each activity, and how that might be able to promote reflection and communication. Meanwhile, the social network analysis from programmatic evaluation offers information about participants' participation status in this community of computing educators. This information is important as we consider the sense of community teachers reported to us after attending DCCE.

4.3.1 Overall meeting quality

The overall feedback from the evaluation surveys gathered at the end of each meeting on the effectiveness of the meetings was positive (Ni, Guzdial, Tew, Morrison, et al., 2011). The participants were asked to rate (on a scale from 1 - low to 4 - high) how

[11] SNA is a methodology for studying social relations among a set of participants. SNA is the mapping and measuring of these relationships among individuals. The nodes (or circles) in a network represent individuals and the edges (or paths) depict the relationships or flow between the nodes.

informative, engaging, and useful they found each agenda item was. Table 7 shows the overall responses across the meetings.

Table 7: Participant Feedback on DCCE Agenda Items

Overall (3.5)	n	Mean	1 (Low)	2	3	4 (High)
Informative	220	3.50	1%	8%	30%	60%
Useful	219	3.48	1%	9%	29%	60%
Engaging	216	3.51	1%	8%	31%	61%

In this table, n is the overall number of ratings received. The overall average rating for all was 3.5 on a 4 point scale, indicating that the participants were satisfied with the overall quality of the meetings.

Also, each meeting had specific, defined learning objectives, and the participants evaluated the degree to which they perceived these learning objectives were met for each meeting. As with the agenda items, participants rated the degree to which the meeting addressed each learning objective on a semantic differential scale from 1 (Not at all) to 4 (To a great extent). As showed in Table 8, the feedback was positive, with an overall average rating of 3.5 for all meetings.

Table 8: Participant Feedback on DCCE Learning Objectives

Overall	n	Mean	1 (Not at all)	2	3	4 (To a great extent)
Learning Objectives	176	3.5	1%	6%	36%	57%

4.3.2 Participant experience and learning

While the feedback collected after each meeting focused on the effectiveness of the meetings, the post-DCCE survey measured participants' experiences over the course

of all the meetings. Among the seven responses of the post-DCCE survey, all participants reported that they enjoyed attending DCCE. They all believed that the decision to take part in the DCCE cohort was a good one and that their participation was a good use of time. The participants rated the overall organization of the DCCE was either "good" (1 of 7), "Very Good" (5 of 7), or "Excellent" (1 of 7). All participants reported that they came to a better understanding of their teaching philosophy and saw connections between their teaching philosophy and teaching practices. Moreover, all of them agreed that they had a better understanding of why they taught their course the way they did.

Through open-ended questions, the participants reported they saw the primary benefit of the course portfolios as aiding in reflection. Furthermore, in terms of how often they would engage in reflecting on their teaching practices in the coming year, all the participants indicated they would reflect either several times (3 of 7) or many times (4 of 7) during each term. In addition, based upon their reflective practices, all of them expected to try a new teaching practice.

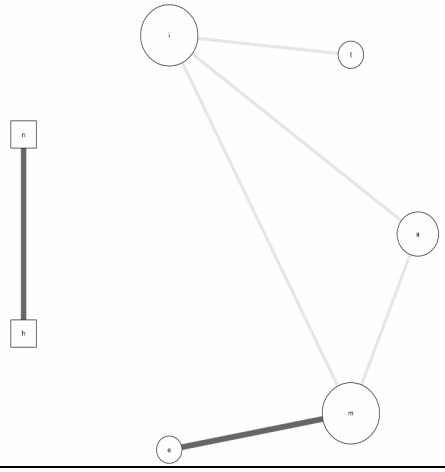
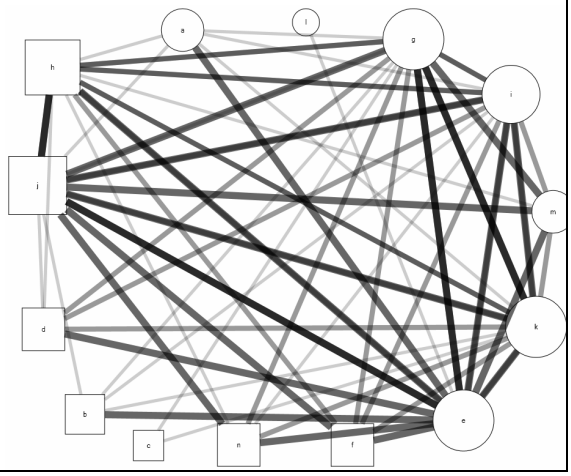
Overall, participants reported that they gained new ideas for teaching and adopted teaching practices from other participants. Furthermore, most participants (6 of 7) reported that they had made definite plans to change their teaching the next time they taught the same course.

4.3.3 Community building

In terms of creating a local community of CS teachers, the participants rated small group discussion and peer observation as the most valuable interactions with other community members. Also, they all agreed that they were better able to provide feedback to colleagues on their teaching after attending the DCCE meetings. All the survey

respondents planned on staying in touch with their DCCE colleagues. They also reported they would contact members of the DCCE cohort in the future for three main purposes: sharing resources, collaboration (e.g., for unit design), and gaining motivation and inspiration from their peers.

Table 9: Participant Partnership Networks

Figure A. Partnerships <u>Before</u> DCCE[12]	**Figure B. Partnerships <u>After</u> DCCE**
	

Results from the social network analysis indicate that participation in DCCE statistically significantly ($p<.05$) increased the number and quality of partnerships formed among DCCE participants. First, the average participant in DCCE did not know 95% of their DCCE peers prior to their participation in the program; at the end of the program, the average participant knows and has collaborated with 88% of their DCCE colleagues.

---

[12] Omitted edges (paths) signify no interaction between participants. Density and Opacity of edges (paths) signify type and/or quality of interaction between participants: **thin line/most transparent** = "*I knew this person but we have never collaborated*"; **medium line/moderately opaque** ="*We shared materials and ideas, but never formally worked on a project together*"; **thick line/most opaque** = "*We formally worked together on at least one project.*" Size of node (participant) signifies degree of popularity (i.e. large circles= popular participants). Squares= Universities; Circles=High Schools.

As a result of their participation, the average participant reports that they have shared materials and ideas with 32% of their DCCE peers and formally worked on at least one project with 34% of their peers. Second, the network of CS teachers also expanded and became more integrated: All participants have merged into a single large community and a more tightly clustered community. The density of the network likewise grew, comparing the network before and after (see Table 9).

In summary, the programmatic evaluation results from the second year DCCE cohort indicate that the participants were satisfied with the overall quality of the meetings. They enjoyed their DCCE experiences and learned through their participation among this group of CS teachers. All these positive results imply that DCCE was successful in achieving its goals of supporting CS teachers as a professional development program. In particular, Chapter 5 reports the findings from study 2 focusing on how such a program supported CS teacher identity development.

CHAPTER V STUDY 2: SUPPORTING CS TEACHER IDENTITY DEVELOPMENT

Study 2 explores how participation within a local CS teachers' community (DCCE) influences teachers' perception of their professional identity. DCCE is aimed at establishing a community where teachers are encouraged to explore their own sense of identity as a CS teacher through promoting teachers' reflection and community building. Table 10 lists the main research question and the hypotheses of this study.

Table 10: Study 2 Research Question and Method

Research Question	Data Collection	Participants
RQ3: How does the participation with a focus on reflection within a local CS teachers' community (DCCE) influence CS teachers' perception of their professional identity?	• Post-DCCE Identity & DCCE Experience Interview (Interview A&B) • DCCE Leader Interview (Interview C) • Administrator Interview (Interview D) • Follow-up Identity & Interview (Interview A) • Supplemental materials: DCCE meeting record, course portfolios & review comments, peer-observation notes)	Teachers: P1, P2, P3, P4 Leaders: L1, L2 Administrators: A1, A2, A3, A4 P1, P2, P3, P4

This chapter reports the findings from study 2 in terms of how each participant's identity evolved through and after their participation in the DCCE 2009-2010 teacher cohort. It first provides an overview of the previous statuses of these participants' sense of identity based on the findings from study 1 (Section 5.1) and then outlines the study method (Section 5.2-5.3). Section 5.4-5.8 present individual stories of each participant's identity features and then summarize potential trajectories of identity development that

occurred with these four participants. The end of this chapter discusses in what ways the DCEE program might have made contributions to those changes.

5.1 The Four Participants

The participants of study 2 are a subset of the participants in the second-year DCCE teacher cohort. Eight teachers including four high school AP CS teachers and four computing faculty in Georgia regularly participated in this teacher cohort from October 2009 to June 2010. Over this time, each participant created one course portfolio incrementally for an introductory CS course (s)he was teaching. They attended face-to-face meetings, reviewed each other's course portfolios as well as visited another participant's classroom teaching and provided feedback. These participants also came back to meet in December 2010 to share and update their teaching over the semester after the June 2010 DCCE meeting.

These four high school teachers volunteered to participate in the DCCE teacher cohort. They had been interviewed through study 1 before they attended the first DCCE meeting. As showed in Chapter 3, these four teachers indicated different identity features before they attended the DCCE program. To refresh our memory, Table 11 outlines their identity features reported before the DCCE teacher cohort started. Overall, Cindy saw herself primarily as a Math teacher teaching CS and more comfortable with teaching Math. John saw himself as a teacher of both CS and Math, but he was more passionate about teaching CS and preferred to teach all CS courses. Pat was teaching both Business and CS combined in a one big class, while trying to build an individual CS class. Ryan was the only one that clearly saw himself as a CS teacher, teaching CS courses and a few elective Math courses for better understanding CS.

Table 11: Pre-DCCE Identity Status of the Four Participants

Participant	Identity (ID)						
	Self-ID	**ID by others**	**Confidence in teaching CS**	**Learning/ strives to teach well**	**Retention/ Commitment**	**Belonging/ Affiliation**	**Other ID features**
P1: Cindy	Math & CS teacher; CS as applied Math	Math & CS teacher	Felt more comfortable with teaching Math	Wanted more ideas for teaching CS	Liked teaching CS, but also want to stay in Math	Business teachers were not peers	Enjoyed teaching CS
P2: John	CS & Math teacher, but more passionate about CS	Math teacher	Felt like he was a better Math teacher than a CS teacher	Pursuing Math degree for better understanding CS; Interested in CS education	Preferred to teach all CS	Looking for community specific for CS teaching	More passionate about and enjoyed teaching CS
P3: Pat	Business & CS teacher	Hired to teach CS	Not confident in teaching AP CS	Eager to learn for the AP CS course	Wanted to stay and build an individual CS course	Felt like she was on island as a CS teacher	Felt a sense of Job security
P4: Ryan	CS/programming teacher	Elective/ advanced teacher	Confident with good grades and student feedback	PD always as goals and interest, with few opportunity	Stayed offering courses as long as there was having student interest	Wanted peer CS teachers to collaborate & address challenges	N/A

5.2 Study Methods

Rather than serving as representative examples, exploratory case studies are chosen to expand and deepen our understanding through empirical inquiry (Yin, 2008). Here, these case studies are aimed at expanding our understanding of CS teacher identity (and identity development), and developing theories about how it could be changed or supported through teachers' participation in delicate reflection activities within a community of computing educators.

Study 2 traced the four teachers' identity perceptions throughout their participation in DCCE through semi-structured interviews right after the DCCE and six months later. Figure 4 lists the timeline of data collection.

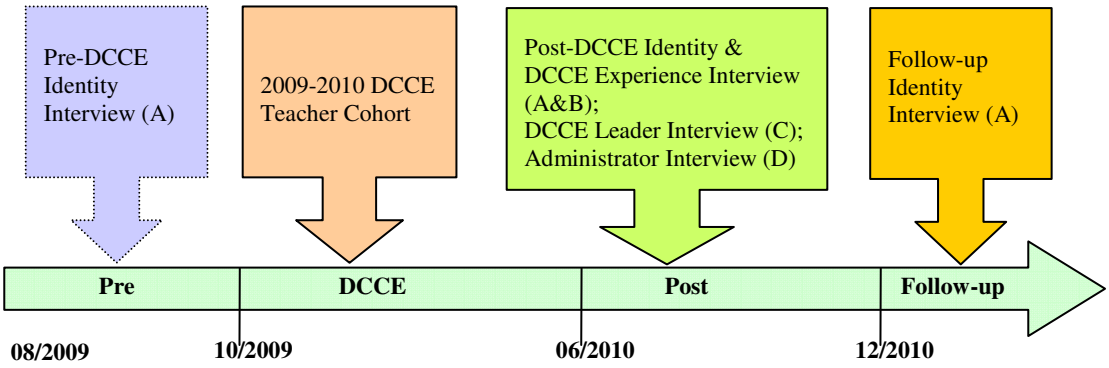


Figure 4: Study 2 Data Collection Timeline

First, the teachers were interviewed using interview protocols A and B right after the June session of the DCCE. Interview A included the same questions related to teacher identity used in study 1. Interview B protocol (attached in Appendix C.3) was used to collect data about these teachers' experiences in DCCE and how their DCCE experiences influenced their sense of identity as CS teachers. Interview C was conducted to collect information from the community leaders about these teachers' participation in

DCCE and identity development from an external view. The semi-structured interview protocol is attached in Appendix C.4. Second, the administrators in their local schools were also interviewed after the DCCE, providing another piece of additional information for understanding these teachers' perceptions of their identity and possible changes of their perceptions.

Third, Interview A (Post-DCCE Identity Interview) was repeated six months after the completion of the whole year of the DCCE meetings, to trace any further influence the DCCE project had on those high school teachers' identity and probably how this change was indicated in their teaching practice over a new semester.

In addition to the above interviews, I also collected related artifacts as multiple sources of evidence, such as the writings of course portfolios, review comments, peer observation notes, and meeting recording files, using them to assist the analysis of the above interviews. These artifacts provided additional information and evidence to help me trace their (reported) identity change. These resources also allow me to link teachers' reports about their participation experience with what actually happened in the DCCE cohort when needed.

5.3 Data Analysis

To answer Research Question 3, I first looked at changes in CS teachers' identity through comparing information about the three dimensions of identity from individual teachers' self-reports collected before DCCE, right after DCCE and half year later. Also, to triangulate findings, I compared these self-reports with what the two DCCE teacher leaders (L1 & L2) and the participating teachers' administrators (A1-A4) said about these

teachers' identity. All these data resources work together collaboratively providing information about these four teachers' identity features at different time points.

When looking at changes in CS teacher identity, I first examined their self identification (Self-ID) of who they are, and compared with the results from study 1. Further, as defined in Chapter 1, five aspects around the three dimensions of the teacher identity construct (attitudes and beliefs, motivation and commitment, belonging/affiliation) were examined, including:

- **Interest and value**: teachers' interest in teaching CS and beliefs in the values of teaching CS;
- **Confidence**: Their sense of confidence in teaching CS;
- **Learning/strives to teach well**: Their willingness to learn and grow the computing program in their department;
- **Commitment**: their commitment to teaching CS;
- **Community**: Whether or not they considered themselves as a member of a CS teacher community.

At the second step, I also compared possible changes in the two items: teachers' definition of computing and their beliefs in the values of computing. At the third step, data about their participation were analyzed, focusing on what parts of the DCCE activities and resources might contribute to the above changes. Some of the collected artifacts were examined as additional information to further understanding about the reported experiences from the participants. Section 5.4-5.7 report the findings of the analysis by each participant.

5.4 Cindy: Became a CS Teacher Community Leader

This section presents the identity statuses of Cindy over the past 1.5 years. I first summarize her identity status before the DCCE cohort, and then present her self-identification and identity features after the DCCE and six months later. In particular, after the DCCE cohort, she presented more confidence in teaching CS, valued the connections made through the DCCE, and started to serve the local community as a teacher leader.

5.4.1 Pre-DCCE status

As discussed in Chapter 3, before attending the DCCE teacher cohort, Cindy identified herself as both a Math and CS teacher. She called herself a Math teacher who also taught CS. She saw CS as part of Math, or Applied Math. She believed that CS applied what students learned about procedures to solve problems in a context of the computer. She felt more comfortable in teaching Math since she was familiar with Math content with her background in Math while teaching CS was more challenging. Although she enjoyed teaching CS as a more interactive and creative subject, she still wanted to stay in Math for job security.

As the only teacher teaching CS courses in her school, Cindy wanted to get connected with other CS teachers. After she had talked to many Business teachers teaching CS courses in her local county, she did not feel that those teachers were her colleagues that matched with her styles/mindsets and could collaborate with in teaching CS. She rejected the current Business teacher group in her local county as her local community since they “had no idea about programming and what they were doing with

this class". She applied for the DCCE cohort looking for peer collaboration and professional growth in teaching CS.

5.4.2 Post-DCCE

After around a year of participation in the DCCE teacher cohort, Cindy still identified herself as a certified Math teacher and would like to continue to teach both Math and CS courses. Meanwhile, she felt more confident about her own teaching in CS through sharing, learning and reflection on teaching practices together with other CS teachers in the DCCE cohort. She adopted ideas for recruitment from other participants and grew the CS program in her department into three full CS classes. She was happy to find other CS teachers who she valued as collaborators. After benefiting from the small community of the DCCE teachers, she was motivated to get more involved in local CS teacher communities by serving as one of the teacher leaders. Next, I'll present evidence that indicate these features of Cindy's identity.

- **Self-ID: Stayed in teaching both Math and CS**

After the DCCE cohort, Cindy still saw herself as a Math teacher, although she was teaching more CS courses this year. Similarly, she reported she liked teaching Math, and Math was easier for her to teach than CS.

> *[Cindy]: "I am a teacher with twelve years' teaching experience. I've taught Computer Science most of my career. I've also taught Math… I like to teach Math classes. That's what I went to school for. That's what I'm certified in. It's the easier part of my day sometimes… I feel like I can get a better handle on Math… Like at the end of the year with Computer Science, I never feel like I'm satisfied with the way I've taught it."*

- **Interest: Enjoyed teaching CS**

Meanwhile, she also enjoyed teaching CS with motivated students in spite of the fact that CS was more challenging for her without a background in CS herself. She would like to have a teaching life mixed with both CS and Math.

> *[Cindy]: "The Math part itself is easy for me to teach. Then I stop into the Computer Science end of it. And I've got students who are highly motivated, students who are bright, students who are completely different personalities than what I deal with in the Math classrooms. Yet, I am constantly reinventing myself as a teacher in the Computer Science classroom. Now, that's not to say that I don't ever do anything new and anything different in Math. I do. But I guess I feel like I can get a better handle on Math…[For teaching CS], I always feel like, 'I need to work on this. I need to work on that.' I think that's good. That makes life interesting. That makes my job interesting and my job fun. So, I like having both ends… It just gives me two different types of my day… If I had all day with my Math students, that would get tiresome. So, having that is wonderful for me because I get a good mix."*

Similarly to what Cindy self-reported, both of the two DCCE teacher leaders saw that Cindy was spending more time in teaching CS over the past year, but she seemed to enjoy teaching both CS and Math and did not want to give up her Math teaching. For example, one of the teacher leaders explicitly commented:

> *[L1]: "Cindy teaches Computer Science and Math, but I don't think you would know that because she is spending her summer on Computer Science. She is working to improve her teaching [in CS]… She did say that she enjoys teaching*

Mathematics and would hate to give that up. So, I think she probably feels allegiance to both... I think she really does love both fields equally."

When asked about the potential influence of her Math background on her teaching of CS, Cindy perceived that her Math background actually helped her to be a better CS teacher, compared with some other Business teachers without this kind of background.

[Cindy]: "I certainly think it helps. I mean, there are a lot of people in the Business Department, across our county in Business Departments who are coming from Business to teach Computer Science. I think, 'How are they going to do this? How are they going to teach kids how to problem-solve and how to think critically if they don't have a strong Math background?' Maybe, I guess, because I have a degree in Math and they don't. But it's truly how I feel. It's truly what I think makes me a good Computer Science teacher is the fact that I have a strong Math background and I can teach kids problem-solving."

- **Learning/strives to teach well**

Through the Post-DCCE interview, Cindy reported that she had learned a lot through the DCCE cohort. Although she did not explicitly re-state that she always wanted to learn more to teach CS better, her active participation in the DCCE cohort and other training opportunities had indicated her attitude. Both the two DCCE teacher leaders and the Business Department chair at her school consistently saw that Cindy was open to new ideas and willing to learn to improve her own teaching in CS. For example, the Department Chair commented:

[A1]: "I know that she continues to want to go to classes. She's always interested in taking classes to learn and going to workshops, anything that comes along.

She's sent me some information about some we haven't been able to send her to. I know that she will continue to do that. She's always trying to do better… She is willing to try to do anything and she wants to continue to do that."

- **Value: CS as valuable to teach for problem-solving**

Cindy still believed that CS (including programming) was valuable to teach for problem-solving: programming was very Math-rich, but it really reinforced students' problem-solving skills and helped them solve problem more creatively.

[Cindy]: "I think [CS] does benefit [students]. I think it really reinforces their problem-solving skills. I think Programming is the perfect environment for problem-solving. You are given a project to do, a program to write, and you need to come up with, even from the very beginning, 'What's the input in this? What are the variables I'm going to use? What am I going to calculate?' So, I think it's extremely important to learn problem-solving skills. I think it really does work hand-in-hand with the Math classroom…Programming is one of those unique areas where we can teach our kids not only how to be creative, but also to be problem-solvers… When you're in a Math class, it's very easy to solve problems. But here you are in an environment where you're encouraged not only to solve problems, but to solve them creatively. So, we'll be teaching our kids Programming."

- **Confidence: More confident in teaching CS**

Although Cindy felt that Math was easier for her to teach with her own Math background, she became confident in teaching CS after the DCCE cohort. While her lack of background in CS made her nervous about teaching CS, she felt more confident about

her own teaching by reflecting on her own teaching and getting affirmed through seeing similarities among the DCCE CS teachers.

> *[Cindy]: "For me, I'm always kind of like, 'Hmm. Do I quite have this? Am I quite explaining this the right way?' You know, so that's part of the reason why the DCCE was good for me, because I could look at it and say, 'Oh, good. Thank goodness I've been doing it the right way.' Because I didn't have that experience. I didn't go to college for Computer Science… I love the challenge that it gives me, but it is something that I struggle with… Also, I think we all have a lot of things that are similar. When I watched [John], I think he and I had some similar styles, similar ways to approach things. It's reassuring to watch him because it makes me feel like, 'Yeah. I'm doing it right.' I'm more confident hearing other people are doing it similarly. That gives you confidence when you don't teach it in a vacuum. That's the most important thing about the DCCE."*

- **<u>Community: Found collaborators from the DCCE cohort</u>**

Cindy had explicitly stated that she did not see some Business teachers she had talked as the ones that she could connect and collaborate with for CS teaching. Through the DCCE project, she found teachers, especially, the two teacher leaders of the DCCE cohort, whose opinions she valued and would like to connect more.

> *[Cindy]: "[L1] and [L2] are two people that I would say I value their opinions and would have loved to have seen them take a section of mine and tell me what they thought of it and give me suggestions and areas to change…Of course, I mean, I talk to [L1] all the time and try to get information from her, and share*

information back and forth with her about our classrooms, and ideas, and things like that. So, not just through the DCCE, but in other cases, too."

She also identified the high school teacher leader (L1) as her main contact and the other three high school teacher participants as the ones she wanted to connect and collaborate in the future.

[Cindy]: "Right now, [L1] is my go-to girl…I'll continue to collaborate with [L1]. I found that's the awesome part. I also found other people to collaborate with… I think that I also connected with Ryan, and with John, and with Pat. I think probably next year when we're teaching, we'll probably be emailing each other and getting ideas from each other. I mean, Ryan and I often. He kept saying, 'Jeez. It sounds like we teach very similarly.' So, even though he has got that whole, 'I disregard grades,' kind of thing, we take the same approach to our lessons as far as trying to get the kids to come about their own solutions. So, I can see him and me emailing and sharing next year."

The DCCE high school teacher leader's comment about Cindy' change through the DCCE cohort confirmed what Cindy just reported above: Cindy was able to identify collaborators and thereby felt supported through the DCCE cohort.

[L1]: "Cindy was an example of a teacher who was teaching in isolation. She does not have a strong relationship with anyone else in her county… I think this year rejuvenated her in that she now sees the need, just constant collaboration, whether you just run an idea by someone else or you ask them for something. I think she feels a lot more excited about new challenges because it's easier to take

a new challenge when you've got someone behind you, rather than doing it by yourself… I think she really now truly believes there's support all around her."

- **Community: Became more involved in CS teacher communities as a teacher leader**

Moreover, Cindy's DCCE experience motivated her to join the local CSTA chapter and even became a leader of it, as an extension of her participation in the local community of CS teachers (DCCE).

[Cindy]: "I joined CSTA [GA Chapter] and became a leader because of the DCCE. I don't want to lose contact. I want to be able to still have a purpose to meet every couple of months, and to learn new things, and learn from each other. What the DCCE gave us was the ability to talk with other people and to see how they're doing things. That's what we're hoping CSTA kind of continues to do is to facilitate a community of people teaching the same thing. I can't be a member of the DCCE next year. So, I've got to go on to the next thing, where I can continue to have some professional contact."

5.4.3 Six months later

Six months after the completion of the whole year of the DCCE meetings, Cindy had been teaching three full-size CS classes for one semester. She was able to implement several changes in her teaching that were identified and planned through her participation in the DCCE cohort over the past year. Some examples of changes she made were: doing earlier free response questions in her AP CS classes, using less worksheets and more online tutorial materials.

In terms of her perceptions about her own professional identity, she still identified herself as a Math teacher teaching both Math and CS, while putting the majority of her energy in CS. She loved teaching CS and was planning to keep recruiting students in CS for the future year. Meanwhile, she felt that she was at a very good status of teaching CS and were therefore better able to help other CS teachers. The biggest change happening was her more involvement in local CS teacher communities. She was serving as a teacher leader in different ways.

- **Self-ID: Math Teacher teaching both Math and CS**

Cindy was putting her main energy in teaching CS this semester. She saw herself still as both Math and CS teacher, or a Math teacher teaching CS. She clearly rejected the title of Business teacher.

> *[Cindy]: "I identify myself as both Math and CS [teacher]. Clearly, now that I'm teaching three CS classes versus [one] Math class, I'm more in that role [of CS]. But I'm really a Math teacher. I'm not a Business Ed teacher. I'm a Math teacher who teaches Computer Science. I really think maybe that's where Computer Science needs to be is in the Math Department."*

Her colleagues in the Math department saw her as the CS specialist, but she was still a member of the Math department.

> *[Cindy]: "They are saying that I'm the Computer Science specialist for [the local] County. I'm a member of their [Math] department. So, that puts a feather in their cap, too… They don't look at it as, 'Oh, but that's her Business part of the day.' They look at it as, 'She's a member of our department, and look, she's a leader in our county.'"*

- **Commitment: Continued recruiting and liked teaching all CS**

Cindy still loved teaching CS, which motivated her to recruit students to keep the CS program. This was not driven by job crisis (as some of the other teachers might have encountered).

> *[Cindy]: "Computer Science is fun. I mean, I love it. You get very different kids. You're challenging them in a way that no other class in our building challenges them. I think it's great. I love teaching it. I'm not worried about my job… I mean, I still recruit because I love teaching that subject area. If I didn't recruit, then it would go away. So, yeah, I guess in a way I'm concerned about the course staying alive. But that doesn't have anything to do with my job security."*

Furthermore, she explicitly said that she was willing to teach all CS if that could happen.

> *[Cindy]: "I mean, if they came to me tomorrow and said, 'We have enough enrollment. Would you teach five AP classes?' I would say, 'Sure.' I love the curriculum that much. I don't know if I could do it for more than a few years…I mean, they've already had that discussion with me this year. Of course, budget, who knows what's going to happen? But they've asked, you know, 'Would you be willing to teach Computer Science all day long?' 'Sure.' I want to stay at least at two full AP classes."*

- **Confidence in teaching CS: "In the groove"**

Similar to what she reported six months ago, her DCCE experience enabled her to learn from other CS teachers as well as to reflect on her own teaching with a structured

course portfolio. She felt much more confident in teaching CS now. Now, her confidence was expressed strongly as "in the groove".

[Cindy]: "I think this is the first year that I have a very organized program. I think I have a really good program where I could almost guarantee my scores, you know. I know my scores are going to be good this year. You know? I don't know. I'm getting to the point where I feel like I'm finally hitting a groove… But I finally feel like I'm getting it together."

- **Community: Not belonging to the Business department**

Cindy saw herself as an outsider of the Business Department in her school, even though CS was offered under this department.

[Cindy]: "I like being part of the Business Department. I like the women that I work with there. But I will always be an outsider in that area. Even though my room now, I'm in that classroom that's right in their pod, I'm never really truly a part of their group. Do you know what I mean? I really am a Math teacher that's just located there."

As a Math teacher teaching Business classes (Beginning Programming and AP CS), she perceived that she was not facing the same challenge as Business teachers might had since she had her job security in Math.

[Cindy]: "They try to include me and whatever. But I don't face the same challenges that they do. I don't have to worry about my job security as much as they do… You know, so there is a huge difference there. I think because of that, because of my job security, you know, when things get tight for them, they're looking my way going, 'Hmm. Maybe I should be teaching that and she shouldn't

be so that I could have some job security.' So, there's always going to be that. That's going to be there. That's caused friction before, the fact that I'm a Math teacher teaching what they would consider to be a Business class. It causes an issue for them. They are very welcoming and they are very including, but I will always be a Math teacher."

- **Community: Valued connection with CS teachers**

Cindy saw the values of making connection with other CS teachers very much and strongly recommended beginning CS teachers to find other teachers to collaborate with, which benefited each other.

[Cindy]: "To find somebody to collaborate with. I mean, I think that was my suggestion to [a beginning CS teacher in her local county] when she came in and observed me last year. [My suggestion] was she really needed a friend that she's going to work with and collaborate with. I think, unfortunately, oftentimes teachers are in this vacuum of CS and they don't want other people to know that they don't know what they're doing. They don't want people to think that they're doing a bad job. So, instead, they continue to do a bad job and don't talk to anybody about it. So, that would be my recommendation: If you're new to it, you need to get with somebody that's willing to collaborate with you and share with you… I think she probably feels that she takes a lot from me, but she also gives a lot to me as well. The fact [is] that I can bounce ideas off her and we can talk about things. Yes, she might be using a lot of my materials, but I tweak and change things based on our conversations, and that's helpful."

In contrast with the CS teaching environment where CS teachers were often in vacuum, the availability of connection with Math teachers actually influenced her attitude to curriculum change. She reported that she felt challenged in terms of updating technology and possible language change for AP CS in the future. However, she was not afraid of a coming major Math curriculum change for her with the availability of other Math teachers to work with. She explicitly expressed that this Math curriculum change would not change her willingness of teaching CS at all.

[Cindy]: "The way the Math groups are set up, we're set up in teams. Everybody shares. If I teach something new next year, it won't be a course that they could throw at me that's brand new and that nobody in our school has taught. Do you know what I mean?… If I stay on the level I'm at right now and I teach that level, but I teach the new curriculum,…it's not like I would be on my own teaching a class all by myself the first year. You know, I'd definitely be in a group of teachers teaching it, collaborating with them, sharing information. So, no. I'm not afraid of having to take on a new Math challenge so then I wouldn't teach AP."

- **Community: Engaging in service for CS teacher communities**

She felt she should and was able to help with other teachers (by serving the CS teacher community). First, as stated earlier, she understood the need of CS community as a CS teacher and had benefited from it before. Second, she became very confident and better organized about her teaching after creating her course portfolio. Thereby, she had things to offer for other teachers.

[Cindy]: "I want to help other teachers be successful. And I think if you look at my scores and you compare them to other schools, I think it would be a sad thing

if they chose a different leader, honestly. And I'm not trying to say that I'm better than everybody else in the district, but my scores say I am. You know. So, I feel like I have something that I could contribute and give back. I also recognize the need for community. I want other people to contribute back to me. I don't want to be teaching it in a vacuum. I think I'm more organized. I think I'm more on top of what I'm doing. I think I'm delivering better instruction because of that [the course portfolio], because I'm more prepared, because I have to be in order to share it. I think that's really made me a better teacher, too… I think as time goes on, you need to take leadership roles and be a contributing member to your school and to fellow teachers and all of that."

In addition to serve as one of the leaders of the CSTA GA chapter and the CS Instructional Specialist in her county, she was currently working on creating a local group of CS teachers and mentoring those newer teachers in her county.

[Cindy]: "I think in order to be a good CS teacher, you have to talk to other people about what you're doing. I mean, in order to be a good Math teacher in my building, I work with six other Math teachers to teach the subject… I think that needs to be the same way for CS. There has to be a place for us to meet and collaborate. That's my goal for my county is to have a group of us together where we're doing this together as a group so that I don't get their reports back and find out that their average is a '1' or a '2'. I mean, that should not be their average. You know, their average should be at least passing, and they're not."

5.4.4 Summary about Cindy

As presented above, over the past 1.5 years, Cindy did not change her main identity as a Math and CS teacher. She stuck to the Math side of her teacher identity. The main features of her perceptions of identity from the three different time points are summarized in Table 12.

Table 12: Cindy's Identity Features (Pre-Post-Followup)

Participant: Cindy		**Pre**	**Post**	**Follow-up**
Identity	**Self-ID**	Math & CS	Both Math & CS; Re-inventing as CS	Both, but really Math
	ID by others	Math & CS	Math & CS; Getting more involved in CS	CS specialist; a member of Math department
	Confidence in teaching CS	Felt more comfortable with teaching Math than CS	Felt affirmed and confident in teaching CS	CS teaching: "In the groove"
	Interest/ Value of CS teaching	Valued CS teaching Enjoyed teaching CS	Same	Same
	Learning/ Strives to teach well	Wanted more ideas for teaching CS	Made change plans to improve teaching; Attending more workshops to learn	More collaboration
	Retention/ Commitment	Liked teaching CS, but also wanted to stay in Math	Grew the program into 3 full CS classes	Kept recruiting to continue to teach CS, but also continued teaching Math
	Belonging/ Affiliation (Community)	Saw Business teachers not as peers,	Found peers to collaborate; More involved in CS teacher community	Serving as a CS teacher leader, creating a local group

However, she gained more confidence for her CS teaching, and was staying at teaching CS. Another interesting change is her perception and participation in CS teacher communities. As we can see in Table 12, she was looking for a CS specific teacher

community before the DCCE, then she was able to found those peers from the DCCE, and further she valued the benefits of participation in a CS teacher community, which drove her to get more evolved in those communities by serving as a teacher leader.

5.5 John: Became a Mostly CS Teacher

5.5.1 Pre-DCCE status

Before attending the DCCE cohort, John identified himself as a Math and CS teacher, teaching mainly Math courses plus one AP CS class. He explicitly expressed that he was more passionate about teaching CS than Math. He saw the value of CS in high schools and believed CS should be a bigger part of education. After expressing his beliefs in the importance of CS and his own passion about teaching CS, John explicitly said that he would like to learn more about CS education to be a better teacher and he would like to grow the CS program in his school.

Meanwhile, even holding a degree in CS, he still felt he was a better Math teacher than a CS teacher due to the lack of support from peer CS teachers. He was eager to have a community of CS teachers, which could help him get through with issues in CS teaching.

5.5.2 Post-DCCE

After attending the DCCE teacher cohort, John felt that he started to become a CS teacher. He still valued and enjoyed teaching CS as before, but was able to make a big growth in his CS classes. He felt more confident with his experience in the DCCE teacher cohort and found ways of improving his teaching. Also, he reported that the DCCE cohort helped him to find a community to join that was specifically for CS teachers.

- **Self-ID: Starting as a CS teacher**

John was able to increase the student number through recruitment efforts during the year of participating in the DCCE cohort. In Fall 2010, he had four sections of CS with around 60 students in total, while he only had one section for the past two years. He felt that being able to teach much more CS made him start to feel that he was primarily a CS teacher.

> *[John]: "I hadn't been a Computer Science teacher until this year. It's probably just a result of now teaching more Computer Science classes and enjoying Computer Science more. I primarily view myself as a Computer Science teacher... I'll be teaching Computer Science four times longer each day than I did last year. That's going to be a great thing for me. I'm really looking forward to that… I'm very excited about it because it's going to give me a chance to teach something that I really, really enjoy. Because most of last year, until this year, I spent most of my day teaching Math. Every other day, I didn't teach Computer Science at all. I only had an hour and a half of teaching Computer Science every other day."*

Similar to what John self-reported above, both of the DCCE teacher leaders sensed his passion in CS and consistently identified that his identity had changed to leaning more towards CS teaching over the past year.

> *[L1]: "I think he would teach Computer Science all day. I think he really likes it. So, I think maybe his identity changed a little bit. I think maybe when he came in, he was 50/50. Now, he leans more to the Computer Science side…My impressions are that he definitely was excited about his increased enrollment and knows that*

it's his primary class next year…He leaned a different way than when he came in."

[L2]: "I think he leans more towards Computer Science. I think that's where his passion…I think John is much more happy, or seemed to be, teaching Computer Science, and more interested in the Computer Science side than he was in the Math side. So, I think he definitely was identifying himself as a Computer Science teacher, and that's where he wanted his follow on to be."

- **Interest: Enjoyed teaching CS**

Similar to what was reported around a year ago, he still enjoyed teaching CS.

[John]: "It's more fun to teach. It would make my year much better and my job much more enjoyable if I had more students, because it's a subject that I love… Teaching Computer Science has just made me really value teaching it so much more over Math. It's just a lot more enjoyable for me."

- **Value (CS teaching): Motivated to grow the CS program**

John reported that he was well motivated to recruit students for CS since CS was his passion. As before, he saw CS as more motivating and relevant to students. Furthermore, he believed that it was very valuable for students to learn since CS offered a context for students to learn problem-solving.

[John]: "I think they learn how to solve problems. It's a good way to hone problem. I think it's a context for learning problem-solving that's going to motivate them to work harder and learn much more than they would, more than a typical student would in the context of something like abstract Math… I would argue that computer skills and computing skills are probably just as important as

Math. So, if we're forcing every student that gets an education to take Math classes, I think we should definitely be doing it with Computer Science."

He also believed that, as a new set of ideas for students, CS was more valuable for students than some advanced Math courses.

[John]: "I think Computer Science is so much more valuable. I'd probably say that for almost all of my students. It's more valuable that they take Computer Science. They're getting exposed to a new idea and they're getting exposed to new ideas that are very important in our society today and especially theirs when they leave high school."

- **Confidence: Felt confident in teaching AP CS, and also found ways of improving**

John felt more confident about teaching AP CS after the DCCE cohort for two reasons. First, he was the only HS teacher holding a CS degree among the DCCE cohort, therefore he was more confident about computing content knowledge. Second, his students had good performance in the AP CS exam over the past year. After seeing how other CS teachers of the DCCE cohort were doing in their classrooms, he felt he was doing a good job.

[John]: "I feel very confident in my ability to teach AP Computer Science. I think part of it is because I have a degree… So I feel like I know Computer Science, the subject and the content, better than the typical AP Computer Science teacher…I guess, based on what I understand other teachers are able to do in their classes, I kind of feel that if I'm an effective instructor, I could get even the weaker of my students to be successful. Right now, I kind of have this measure of success being

the AP exam… My AP scores have been really good. I feel that this year, they're going to be very good. I think everyone passed. So, I feel confident about that…I feel very confident. I feel that my students are getting a very good Computer Science education when they take my class."

Meanwhile, he identified room to improve and a new focus of his teaching. After seeing other teachers' practice through the DCCE cohort, he wanted to focus on teaching for understanding computing concepts instead of teaching to test.

[John]: "I feel like I'm now getting much better at getting my students to be successful with the AP exam, and either move beyond that into other areas that are more important than just success in the AP exam. I feel as a new teacher, that was kind of a first challenge. First, I wanted to make sure my students could do well on the AP exam. But now, I want to make sure that they're learning Computer Science and getting a good appreciation of Computer Science… Going and seeing Ryan, Ryan doesn't focus on tests as much, and I realize that the AP exam really doesn't test necessarily the most important ideas in computing. So, I think Ryan does a really good job of probably being more efficient than I. So, I know that I do have a lot of room for improvement."

He further explained how another participant (Ryan) inspired him to improve his own teaching, which he had been very comfortable before.

[John]: "He just seemed so much more efficient in his teaching than me. It really inspired me a lot and made me realize I've got a lot of room for improvement. I always knew that I had room for improvement, but I also felt pretty comfortable that I was one of the better high school Computer Science teachers around, just

because I hadn't really met any others than the ones that I had. It just didn't seem like they were making as much progress as I was with my classes. But after seeing him teach, I realized that there were definitely a lot of things I could do in my own teaching to improve. So, that was one big moment for me to see."

- **Community: Found a community to join**

Before the DCCE cohort, John was looking for a group of CS teacher peers to connect as he had been offered for his teaching in Math. Through the DCCE cohort, he felt that he found a community of CS teachers to join, which often did not exist for him before participating in the DCCE teacher cohort.

[John]: "I felt like I didn't belong to a community at all of CS teachers until the DCCE. But now I have a lot of teachers that I would feel fine about either calling up or emailing. That did not exist before. That's one reason I think it's so important that we have things like DCCE, because CS teachers are usually pretty isolated in high school."

He made connections with the other three CS teachers in the DCCE cohort. He saw these teachers as his peers who were motivated CS teachers. These teachers were therefore different from some other teachers he met before.

[John]: "I have noticed major differences at workshops that [a local computing researcher] does with teachers there, between myself and some of the other teachers, and the knowledge they have of Computer Science… But I think in this group, the teachers were just so motivated. I guess that's partly why they were all there, a part of this group. I think they've been able to teach themselves what they needed to be effective Computer Science teachers."

5.5.3 Six months later

After teaching a lot more CS over the past one semester, which was 6 months after the DCCE cohort, John felt that he was a mostly CS teacher. He enjoyed teaching CS and was very committed to CS teaching.

- **Self-ID: A mostly CS teacher**

He now felt that he was a mostly CS teacher, enjoying teaching CS more.

[John]: "I've always wanted to be a Computer Science teacher. Now, I feel like I am mostly a Computer Science teacher. I teach Computer Science. I have [four] groups of Computer Science students and one group of Math students. I definitely am more passionate about Computer Science. I enjoy teaching it more. If I had a choice, I would teach nothing but Computer Science. So, I would definitely identify myself as being a Computer Science teacher that teaches Math on the side."

- **Confidence: More effective as a CS teacher**

In the summer before, he made plans to improve his teaching and focus more on students' understanding of CS instead of only on the AP exam. Now, he felt he was teaching better and students were also learning computing concepts better this semester.

[John]: "I think I'm probably doing a much better job this semester and I'll have many more kids pass the exam. My top kids will learn more than my top kids last year learned. I think I'm ahead of where I was last year at this point. I definitely think I've gotten much better. I think, also, the kids are learning. They're more

interested in what they're learning this year, too. So, last year, I was very successful at training these kids to do well in the AP exam. But this year, I think I'm doing a better job of training them to learn computing concepts better… I think I've done a much better job of that this year. And I think my AP exam performance will be better this year."

He further explained why he felt himself more effective in teaching Math before and what contributed to his increased confidence in teaching CS. He believed that having experience in teaching CS and the learning from the DCCE cohort were the major contributors to the growth of his CS teaching.

[John]: "I think I have changed there. I think just the experience of teaching Computer Science last year and now teaching it four times in a row the same topics, I feel like now I'm a better Computer Science teacher now because I've just got that experience…I had taught Math courses so many times, most of my day. And I have taken classes and learning how to teach. But I've never had any of that for the Computer Science. So, maybe it's just the collaborations with people at DCCE that's caused that change. I think it's also just that experience. Right now, I would say I feel more effective as a Computer Science teacher… Last year I definitely felt more effective in teaching Math. So, I think there's definitely been some change."

- **Commitment: Would like to teach all CS**

He explicitly expressed that he would like to continue to teaching CS and even teaching all CS if possible. He was strongly committed to teaching CS. He further

explained that he would even leave the current school if he was pushed to teach more Math next year.

> *[John]: "If I had a choice, I would teach nothing but Computer Science… The only reason I wasn't doing that before is because I just didn't have enough students. So, now that I've been in school for awhile, I've been able to get my numbers up with recruitment. So, ideally, I would do nothing but teach Computer Science all day… I'm afraid that next year they're going to want me to do more Math and that they could possibly take away some of the Computer Science classes. I hope that doesn't happen. I would probably leave the school if it did happen."*

He further confirmed his willingness of continuing teaching CS. If the current school decided to drop some of the CS courses due to Math teacher shortage next year, he would like to move to a different school where he could (start to) teach AP CS.

> *[John]: "There's probably going to be a teacher shortage [in Math]. Class hasn't been going up. I think a few Math teachers will leave… Taking me away from my current Math teaching load would make things even worse. I'm afraid they just wouldn't do that. Instead, they would drop some of the Computer Science courses… At this point, I would just say, 'Well, if you do that, then I'll move to a different school'… I know there are other schools that would allow me to do that. So, that's where I'm at right now, and I'm comfortable doing that if I have to because I love teaching Computer Science. I'll do that, even if I have to move to a different school."*

- **Community: Willing to mentor CS teachers**

John explicitly gave credits to the DCCE cohort for his increased confidence in teaching CS. He believed that the DCCE helped him grow his confidence by offering a community to talk about CS teaching.

> *[John]: "I think DCCE definitely did help [me feel more confident]. I think it was just being a part of a community of teachers that you can actually talk with about teaching. I think that's so important and it's something Math teachers get because of the nature of the Math Department. You've got other people to talk to. But there's not a Computer Science Department… I think that was the perfect thing for me was to sit in a room and talk about teaching Computer Science, because you just don't get that experience."*

Since he felt very confident about his own teaching and was good at finding recourses online, he did not feel that he might need to regularly contact other participants for help next year, but he was willing to mentor newer teachers.

> [John]: "As far as when I'm teaching next year or next semester, I probably won't contact them much, because I feel like I'm really good at finding good information in the online community… [Help newer CS teachers?] Sure! I think my dream job would probably be to work at a college and try to teach people to be Computer Science teachers, to study Computer Science education and learn how to be very involved in the community in a way that you cannot be involved if you just teach one group of high school students."

5.5.4 Summary about John

Over the past 1.5 year, John did not change his passion in teaching CS. He was able to teach more CS and enjoyed teaching CS more. He felt himself mostly a CS teacher. He planned to continue to teaching CS and would be willing to make efforts such as recruiting and moving to another school to enable himself to continue to teaching CS. Table 13 summarizes the features of his perception of identity before the DCCE, right after the DCCE and six months later. Overall, John's self-identity moved toward more as a committed CS teacher, showed in the pink row of Table 13.

Table 13: John's Identity Features (Pre-Post-Followup)

Participant: John		**Pre**	**Post**	**Follow-up**
Identity	**Self-ID**	CS & Math teacher, more passionate about CS	Starting as a CS teacher	A mostly CS teacher
	ID by others	Math teacher	Math teacher and computer person	Math department chair
	Value/interest in CS teaching	Valued CS teaching; Passionate	Same	Same
	Confidence in teaching CS	As a better Math teacher than a CS teacher	Confident in CS, also seeing room to improve	Teaching better; Students learn computing concepts better
	Learning/ strives to teach well	Math degree to better understand CS, interested in CS Ed	Same	Same
	Retention/ Commitment	Preferred to teach all CS	Same	Even willing to move to be able to stay in CS
	Belonging/ Affiliation	Looking for communities specific for CS teaching	Found a community to join, with motivated CS teachers	Willing to mentor other teachers

Increased confidence for teaching CS was another major change over the past 1.5 years for John (indicated in the blue row). He felt himself better at teaching Math than CS, then started to felt more confident in teaching AP CS with good exam scores, and now he saw himself as an effective CS teacher and could help students not only prepare for the AP CS exam but also gain good understanding of computing concepts.

A third change for John lay in his sense of belonging to a community of CS teachers, as showed in the purple row of Table 13. He was looking for CS specific teacher community before the DCCE, and then he was able to found motivated CS teachers as his peers from the DCCE and valued the benefits of connecting with other CS teachers. Now he felt he was good at teaching CS and willing to mentor newer teachers to help them become better CS teachers.

5.6 Pat: Drew Back to Business Teaching

Pat is a different case. She started with lots of passion in teaching CS and growing the CS program at her school, but ended up with losing commitment to CS teaching over the past 1.5 years.

5.6.1 Pre-DCCE status

A year and half ago, Pat identified herself as a CS and Marketing teacher since these were the two subjects she taught in the Business Department. She understood the importance of computing for students and saw the values of offering CS courses. Therefore, she was working on building the CS program in her school, while she was in a special situation offering courses of both Marketing and Programming combined in one class.

Pat was the only CS teacher, and that was her first year of teaching AP CS. She felt herself "on an island" and intimated. It was challenging for her to learn the programming language (Java) and put materials together for the AP CS course. She felt that she was isolated and would like to learn specific content as well as teaching techniques. She also wanted to get connected with other educators who cared about teaching CS. She complained that putting some Business teachers who did not want to teach CS into this CS education community hurt the program. Still, she would like to continue to teaching CS for a sense of job security.

5.6.2 Post-DCCE

The story of Pat was very different from the other participants. Her attitudes and perceptions about herself related to teaching CS were significantly impacted by the temporary RIF (Reduction in Force) procedure from her county that happed to her at the end of the DCCE cohort. She felt her work was not valued by the administration, which greatly hurt her commitment to teaching CS. She was not sure if she should accept a re-hiring offer as a CS teacher.

Meanwhile, the DCCE cohort did influence her sense of identity in a positive way. She was an active and engaged participant. She felt herself more comfortable with teaching CS after the DCCE. Also, she felt that the DCCE group helped to solidify her commitment to some extent.

- **Self-ID: Pending**

As stated earlier, Pat was working on growing the CS class so that she could teach a whole CS class instead of mixed sections of CS and Business in one class. At the end of the DCCE, she was able to recruit enough students for an individual CS course for the

next semester. However, she was suddenly laid off by the RIF process of her county due to budget cuts. She was waiting for a re-hiring process to be able to teach for those recruited students. Therefore, she felt her job was not being appreciated or valued by the administration. She was wondering whether she should continue to teaching CS even if she got re-hired later on.

> *[Pat]: "You know, I understand Computer Science. I understand the need for it. I got so much out of my students and what they took from me and took out of themselves, whether I helped motivate them or they motivated themselves... I question not whether I would like to teach Computer Science or not. For me, it's not being appreciated. To have enough gumption to say, 'Here's a teacher that did all of this, and I'm going to let you go.' You know, I'm really inclined not to sign my contract because I don't want to go back and work for an entity that feels that way of me. I don't work in the corporate world that way. I'm a corporate person again. I'm not going to work in that."*

- **<u>Confidence: Felt free from fear in teaching CS</u>**

Pat felt CS was difficult to teach and was intimated before the DCCE since that was her first year of teaching AP. After the DCCE cohort, she felt more confident. She reported that the DCCE helped her go through the fear of teaching AP CS for the first time.

> *[Pat]: "It's difficult to teach and do your lesson plans, and do everything required, and maintain and keep up with technology… I probably struggled with the fear of teaching such a technical subject, having not been coding myself for so long… So, I got through that. It was nice to go through it with a DCCE group to*

be there, because every month, as we've talked about, was such an inspiration and really kept us going. So, I thought that was huge. I got through that struggle... I worked through, struggled through learning the content and being able to teach it as I went through, and I feel much better about that."

- **Commitment: Solidified her commitment to teaching CS**

Although Pat felt she was greatly hurt by the administrative decision of the RIF process, she still appreciated that the DCCE cohort offered a community for her, which helped to solidify her commitment to CS teaching. She saw this was a community of CS teachers who thought logically and helped her enjoy CS and see the value of it.

[Pat]: "The [DCCE] group, for me, was so helpful in solidifying or making me want to continue to teach in Computer Science, because it was a group where I could share a Computer Science question, an issue and how did you deal with this. We're on islands. I said the lonely island in my presentation and it's so true. It just stinks… So, what happens is you get stuck on this island, and you lose your motivation. You lose morale, everything… A lot of us, if you're truly a computer person, programmer-type, you have to be logical in what you think… So, here's a group of people that all think like this. The ones that survive really is we all logically think… The group has helped me enjoy Computer Science, see the value of it. I feel great about it."

- **Community: Felt the value of making connections**

Pat felt that she had the DCCE group as a community and connecting with this group of CS teachers was very valuable. For example, this kind of connections helped her

and other teachers to see the similarities and also learn from differences among each other.

[Pat]: "From a connection perspective, that was strength. Connected from a collaboration perspective, [We saw] lots of similarities as far as what we teach, or how we teach it, why we want to teach it. Yet, there are some differences to learn from and to think, 'Oh, maybe I should think a different way.' You know, I could go through every single member and say I got something from each of them to take away, either from a motivator of me as a teacher, or for content, or a new way to think about it."

Seeing the merits of making connections with other CS teachers, she was planning to connect with several of the DCCE participants in the future.

[Pat]: "I think you probably sensed it in our last meeting. A few of us are fearful that we're not going to have this next year, and we're going to fall right back into where we were. So, therefore, what I got away from it every month was huge. Obviously, I keep in touch with most of the folks… Hopefully, you know, we'll definitely stay in touch. If I continue teaching, then I would definitely see myself collaborating with [Ryan] and keeping in touch with [John]."

5.6.3 Six months later

Six months later, Pat had accepted the re-hiring offer and returned to teaching the CS courses in her school. However, her commitment to teaching CS was weakened. She reported that she now preferred to teach Business instead of CS, or she might even leave the teaching profession in the future since she was disappointed with the current

educational system. She believed that even if she still valued CS herself, currently it was not a valued field to teach within the current educational system.

- **Self-ID: Business and CS, rehired for CS**

Now Pat was rehired to only teach CS for the first time. However, she did not see herself as a CS teacher, at least not strongly.

> *[Pat]: "I'm a Business Education and Computer Science teacher. This semester I'm teaching two Computing in the Modern World and one Beginning Programming. I was only hired back because of the Computer Science, because they didn't have anybody to teach AP [next semester]. Otherwise, I wouldn't have been hired back. So, they wanted to keep the AP course. Otherwise, it would have gone away... [I'm a CS teacher?] It just depends on the year, to be honest with you. Before, when I taught, I was a Business Education teacher. I did a Marketing class as well… It just depended on what they needed and what the kids sign up for. So, right now, I'm a Computer Science teacher and leave it at that."*

In contrast with Pat's unsureness in identifying herself as a CS teacher, her students actually expressed their respect and need of her teaching in CS and the Business department chair (A3) confirmed the important role of Pat as a CS teacher.

> *[A3]: "I will have to tell you that last year when she was one of the ones RIFed, her students were very upset about it… [They] had a petition. The whole school, a bunch of our kids signed it to send in about not getting RIFed with some of our teachers… When they found out that she was back, many of them were just ecstatic… I really fought to get the Computer Science position back because there is definitely a need for that. So, that's her primary focus now. I told her just put*

all her energy on that. So, she's been out recruiting. We have one full class and maybe a partial class next semester of just AP Computer Science. But there was no one on staff that could replace her."

- **Confidence: Felt more comfortable but still challenged in teaching CS**

Pat reported that she now felt more comfortable with teaching CS courses as a result of the DCCE cohort. However, she still felt challenged by the lack of resources.

[Pat]: "As a result of DCCE, I have more confidence as I approach things this year as well as resources I know I can go to for help and support. I am looking at changing content a bit… I will also work on bettering my approaches to teaching the harder material, again, using the resources learned from my cohorts… I definitely feel better. The problem is at the end of the school year last year, as you remember, the wonderful Technology Department here deleted my entire hard drive. So, I lost everything. [L1] had given me stuff, but I can't find it. I still have no books, other than the old Big Java's with no teacher edition, no supplementary files. You can't access it online anymore. So, there is nothing… I can't make them do it at home… So, that's kind of like probably the biggest things. But, you know, I feel more comfortable."

- **Commitment: Weak commitment to teaching CS**

Pat was passionate about teaching CS a year and half ago and worked hard to recruit students. Now she had a larger number of CS students. However, she did not feel committed to teaching CS. She literally expressed that if she could make a choice, she would prefer teaching Marketing instead of CS. She might also go back to industry if another cutoff happened to her next year.

[Pat]: "If I could make a choice, I'd know I probably would prefer teaching Marketing, to be honest with you at this point… As you know, being laid off after being as perfect an employee as one could be at my school and in my county really took its toll… I am not sure what I will do next year. Cuts are looking eminent again so I am bracing for the lay off again. I am also exploring heading back to the corporate world which is almost a shame. As I told you, I still enjoy [teaching] my students, my time with my students, and I am happy to give those that have taken many classes with me the chance to take AP before they graduate."

She further explained that her decision was driven by her perceptions about the current situation of computing education. She sensed that there were many constraints in teaching CS, and CS was not valued by administration.

[Pat]: "What made me feel this way? I think the lack of professionalism and respect for the value of CS along with the behaviors of many of my peers. Because of the constraints that are here for us in Computer Science and the lack of interest from both the administration and students. [Because of] that, and also the amount of work that has to go into keeping yourself current with Computer Science. It's an immense amount of work. Whereas, other disciplines, they set their lesson plans and sit there for seventeen years and get paid more money than you do… There just isn't a field for [CS] in Georgia… It's just when it's not appreciated and when administration and the county, and around you doesn't put an emphasis on it."

5.6.4 Summary about Pat

Over the past 1.5 years, Pat's professional identity shifted from as a Business teacher working on growing the CS program to only teaching CS. However, this was not a necessarily positive change for her. Her commitment to teaching CS was weakened by the external factor (the RIF situation). She did not feel strongly about continuing teaching CS and even preferred to teach Business.

Table 14: Pat's Identity Features (Pre-Post-Followup)

Participant: Pat		**Pre**	**Post**	**Follow-up**
Identity	**Self-ID**	CS & Business	CS & Business, but felt shaky	CS, but prefer Business
	ID by others	Hired to teach CS and build Marketing program	N/A	Rehired to teach CS only
	Interest/ Value of CS teaching	Valued CS teaching	Same	Same
	Confidence in teaching CS	Not confident in teaching AP CS	More confident, did not fear	More comfortable but still challenged by the lack of resources
	Learning/ strives to teach well	Eager to learn for the AP CS course	Had a full CS class, but felt her teaching not valued	N/A
	Retention/ Commitment	Stayed and wanted to build an individual CS course	Not sure/pending	Weak commitment, Preferred teaching Business
	Belonging/ Affiliation	Felt on island as a CS teacher; wanted peers to collaborate & address challenges	Found peers, plan to continue to connect	Connection built
	Other ID features	Felt a sense of job security	N/A	Felt the need of teaching CS for students

Table 14 summarizes the features of her perceptions of professional identity before DCCE, right after DCCE and six months later. Sadly, although Pat achieved an *external* CS identity from the administrative perspective as she was rehired just for teaching CS, her self-identity as a CS teacher was weakened with less commitment in CS. This change was showed in the pink and orange rows of Table 14.

However, the DCCE cohort still had some positive impact on Pat. She felt the connections she made through the DCCE cohort were valuable. She also gained more confidence for teaching CS and felt motivated and inspired by other CS teachers.

5.7 Ryan: Became Able to Contribute to a CS Teacher Community

Ryan was a private school teacher teaching programming courses and sometimes also Discrete Math. He saw himself as a CS teacher and this identity did not change throughout his participation in the DCCE teacher cohort. Meanwhile, he felt himself isolated as a private school teacher. He found peer teachers to connect through the DCCE cohort. Through the participation in DCCE, he recognized that he was doing a good job teaching his students and thereby should and also had things to share with other teachers to help them.

5.7.1 Pre-DCCE status

Ryan identified himself mainly as a CS teacher. He had a broad definition of CS and saw the values of CS for every student. As the department chair, he built four CS courses in his school including Introductory Programming in VB, AP CS in Java, Data Structures in C++ and one senior design course. He was confident in teaching those courses with good student feedback. Meanwhile, he was eager to learn more from teachers outside of his school and hoped to have a group of peer CS teachers.

5.7.2 Post-DCCE

After the DCCE teacher cohort, Ryan felt more confident about his teaching. Through DCCE, he was able to see his teaching affirmed by other CS teachers. He also felt himself now belonging to a group of CS teachers and inspired to recruit more students for AP CS.

- **Confidence: More confident and felt affirmed about his teaching**

Ryan was already confident about his teaching before as he usually received good feedback from his students and they had good grades in his classes. Meanwhile, he was isolated and would like to learn from teachers in other schools to keep his school at good level. He reported that the DCCE teacher cohort enabled him to validate what he already did well and identify good teaching practices to continue through communication with other members. Through this kind of affirmation process, he became more confident than he came into the DCCE cohort.

> *[Ryan]: "As a result of this year, I feel a lot more confident. I felt like I was succeeding in that capacity before, but this year with my peers, I feel like I have enough background and that I'm doing a reasonably good job…I guess I was very surprised at how excited [John] was about his observation of my class. I didn't feel it was that exceptional a job. But somehow the questioning process and brainstorming discussions seemed to really be inspiring to him. I realized it's something I need to focus on more than I already do, because it has a potential. I guess I felt affirmed in a way I had never felt before. I felt that there's a place for my approach and I could incorporate some of those strengths that other teachers*

were bringing. I felt affirmed for having some of the ideas I had. So, I did leave with more confidence than when I came in."

- **Community: Felt belonging to a group of CS teachers**

Ryan was the only private school teacher among the DCCE teacher participant. He preferred discovery learning and did not like some traditional ways of teaching. He felt nervous about himself being different from other teachers at the beginning, but felt belonging to the DCCE group finally.

[Ryan]: "I do feel I belong in it now. I think some of the fears I've voiced about starting the DCCE was a fear of in comparison to other teachers not doing the things traditional teachers do, such as emphasis on grades, such as certain types of feedback."

The DCCE high school teacher leader also captured this transition of Ryan's participation in this community. Ryan was a different member in the group with different teaching pedagogy. However, he was able to understand the difference and found ways of learning from this group throughout this year, as the teacher leader said below:

[L1]: "He is not a traditional teacher. He doesn't believe in a lot of the mainstream classroom ideals that just sort of embody traditional education… Most of us, this is what we do. Ryan, 100%, full-heartedly believes in discovery… He was definitely the different person in the group. He did not seem to have any need for content. He seems to understand it pretty well. As to pedagogy, when he hears something that's so opposite of what he does, I don't think he digested it the first half year. Because maybe his first impressions were, 'Oh, that would not work in my world.' But I saw him transform throughout the year… I think he's

now willing to hear those ideas and figure out a way to bring them into his own classroom… I definitely saw the transformation. I think he picked up some good ideas throughout the year. He's also excited about going back and trying."

- **Community: Seeing the value of sustained community of CS teachers**

After the one year's participation in the DCCE teacher cohort, Ryan was able to see the values of having regular communication with other CS teachers as a profession. He perceived this was a fruitful experience for him.

[Ryan]: "Something I learned was how essential it is to have dialogue with other teachers of your subject area. I've had dialogue with other teachers not in my subject area, and that's been good. But nothing will compare with it. So, even recommending to a new person coming next year, they really need to lean into it and see how you can practice being a professional colleague. This was a good start in that for our Computer Science… I learned [the need] of having a sustained professional dialogue with other teachers of CS. So, that's directly from DCCE, even though it's something we've always known…This is the first experience that really has underscored how fruitful it could be."

Therefore, he was planning to stay connected with some of the CS teachers in the future.

[Ryan]: "I do think I have a network now that I haven't used much. Although, I've had, as a result of this year, I've had more conversations with teachers outside my school than I have in most of the years prior. I haven't called them very often yet. I definitely would see calling, provided I knew where I was going and knew I had the time to plan for that."

- **Strives to teach CS: Inspired to offer AP CS for more students**

After talking to other DCCE teachers and seeing their CS programs growing over the past year, he was motivated and inspired to try to recruit more students for AP CS by offering it earlier and teaching it at lower level.

> *[Ryan]: "[What] I'm considering is to offer AP Computer Science as the very first class or maybe the second class that anybody would take. It's a year long. But I would teach it then at the lower level… So, that might be the way to catch a lot of people early, and instead, push the real advanced work afterwards… What I'm hearing through some of the discussions in DCCE, this year, is that they're able to offer a first experience in Computer Science as the AP with some success, and that they're able to push and pull to get students to join. They see nothing wrong with doing that. So, what I'm really doing is trying on a different personality mode to see if, 'Okay. Maybe if I act like a recruiter or if I do a little more pushing and prodding, that I can grow the numbers.'"*

5.7.3 Six months later

Ryan still identified himself as a CS teacher, but felt more comfortable with sharing his teaching. He saw the need and the benefits of CS teacher community, and realized that he could contribute to the community more by sharing more about his own teaching instead of just learning from others.

- **Self-ID: Mainly CS**

As before, Ryan saw himself mainly as a CS teacher teaching programming. He also sometimes taught elective Math courses that were related to CS.

[Ryan]: "I usually introduce [myself as a] Computer Science [teacher]. But I've taken to starting to always say both. I teach Math and Computer Science in high school. I usually will put the word Programming in there because not everybody understands what Computer Science could be, even though Computer Science is broader than the Programming part… For the Math I teach [e.g., Discreet Math], I should mention that the Math I'm teaching primarily is very, very related to Computer Science."

- **<u>Confidence: Felt more comfortable to share</u>**

He used to feel uncomfortable with sharing those aspects of his teaching that he saw as different from other teachers. Through communication in the DCCE teacher cohort, he understood the meaning of sharing among peers. Now he was more comfortable with sharing and also felt affirmed about those good parts of his teaching by other teachers' feedback.

[Ryan]: "I felt like I was on shaky ground, even though I was getting good results from students. I knew I wasn't teaching the way I thought everyone else was teaching. I thought that was something I should hide. But reading other people's and engaging with what they produced made me realize it's a dialogue and it kind of took away any of the fear or discomfort about it for me... When people would push back because they disagreed, that wasn't a problem. It was just differences of opinion. When they looked at something and said, 'Hey, you know, that was interesting.' Or, 'I like what you're talking about.' It was affirming and encouraging to try to continue to do that or to look at it, not as something you needed to hide, but something that could be shared."

- **Community: Encouraged to share as part of professional life**

The original motivation for him to attend the DCCE teacher cohort was to learn from other participants to find answers for the problems he was trying to solve. For example, he was trying to find out how other teachers addressed the need of weaker students. However, through conversations with other CS teachers, he was encouraged by other DCCE teachers to share his teaching more in addition to learning from others.

> *[Ryan]: "One of the goals I had was to try to address weaker students at that time. That was one reason for [attending the DCCE]… I've never felt supremely confident and I've never felt an expert, partly because the background is not one that was trained as Computer Science…This past year and a half, I have been encouraged by my [DCCE] colleagues to have a little more pride in how I do what I do and what I select to do, and a little prodding to try and share that with other folks who might wish to do something similar. So, I guess in some ways I'm finding more of a professional voice and recognizing that maybe it's a little selfish not to share it. You know? As much as I want to not be stale and find out what other people are doing, other people want to know what I am doing as well."*

- **Community: Felt able to share to benefit other teachers**

Ryan felt his teaching was affirmed through communicating with other DCCE teachers, which also helped him to identify things valuable to share with other teachers. This was a big shift for him. Before the DCCE teacher cohort, he did not recognize there was a value of sharing his teaching with other teachers since he felt discomfort with sharing his *raw* ideas or *immature* ideas.

[Ryan]: "I think I remember when we first talked a year and a half ago that I expressed kind of fear of being involved in the DCCE. It wasn't fear. It was discomfort. It was like, you know, 'I want to try something new, but at the same time, what's it going to look like to show people? Why would anybody want to know what I'm doing?' You know, that kind of stuff. So, it's been a change in a year… When they looked at something and said, 'Hey, you know, that was interesting.' Or, 'I like what you're talking about.' It was affirming and encouraging to try to continue to do that or to look at it, not as something you needed to hide, but something that could be shared… So, that was definitely during the DCCE experience… I guess in teaching, when you do things satisfactorily or well, you often get no attention. Right?... [The administration] don't come and tell you to go share this with other schools… So, twenty years of that makes you assume nobody wants to know or what you're doing isn't anything special. I'm glad to feel more like what I'm doing is useful to people besides my students. I was glad to have that. I was surprised and glad to have people say that."

5.7.4 Summary about Ryan

As presented above, Ryan's self-identity as a CS teacher continued over the past 1.5 years. He felt himself mainly a CS teacher and felt confident about his teaching. Through the DCCE teacher cohort, he was able to see his teaching affirmed by other CS teachers and found things to share with for other teachers. Table 15 summarizes the features of his perception of identity before DCCE, right after DCCE and six months later. Overall, Ryan became more comfortable with sharing his teaching and saw it as a

way to contribute to the CS teacher community as showed in the blue and purple rows of Table 15.

Table 15: Ryan's Identity Features (Pre-Post-Followup)

Participant: Ryan		Pre	Post	Follow-up
Identity	**Self-ID**	CS	Same	Same
	ID by others	Elective, advanced teacher	Same	Same
	Interest/Value of CS teaching	Valued CS teaching	Same	Same
	Confidence in teaching CS	Confident with good student feedback and grades	More confident and affirmed	More confident; more comfortable with sharing his teaching
	Learning/ strives to teach well	PD always as goals	Learning to address challenges	Kept learning for new technology
	Retention/ Commitment	Continued offering courses for interested students	Motivated to recruit more students	None
	Belonging/ Affiliation	Wanted peer CS teachers	Felt belonging to the DCCE community	Encouraged to share; Saw the need and his ability to share

5.8 Discussion: CS Teacher Identity Statuses and Trajectories of Change

The above sections (5.4 - 5.7) presented the four individual teachers' identity features at different time points that were indicated mainly through these teachers' self-reports with the aid of comments from the two teacher leaders and local administrators. This section applies two major theories in identity research as the lenses to further understand these teachers' identity development. First, I use Gee's four ways of looking at identity (Gee, 2001) to discuss what types of identity these four teachers developed

through the DCCE cohort. Second, I apply Marcia's identity status theory (Marcia, 1966) to examine these four teachers' identity statuses and how these statuses have been changed throughout the DCCE.

5.8.1 Affinity identity vs. institutional identity: Two common changes

Although these four teachers present different identity features, there were two common changes that occurred to them over the past 1.5 years. First, all of the four teachers were able to build some sense of belonging to the local CS teacher community at different levels. Second, all of them learned from the community activities and found ways of improving their teaching with increased confidence in teaching CS. Take Cindy as an example, the availability of the DCCE teacher group (as a local community) drove her to move from the status of lacking (CS teacher) peers, to having found peers for collaboration, and then to serve as a teacher leader after benefiting from the community and getting her CS program growing larger and better organized.

As discussed in Chapter 1, identity is defined as "being recognized as a certain kind of person in a context" (Gee, 2001). Therefore, people can have multiple identities connected to the social contexts they are located in. Applying Gee's four ways of looking at identity, what these four teachers were able to develop through the DCCE teacher cohort is more as their *affinity identity (a-identity)*. The a-identity perspective sees "we are what we are because of experiences we have had within certain sorts of affinity groups" (Gee, 2001). People build their a-identity in the process of forming affinity groups or communities of practices. For these four HS teachers, they joined the DCCE teacher cohort with other CS teachers as an affinity group. Through participation or sharing, they were able to build a sense of belonging to this group. As reported in earlier

sections, these teachers saw similarities among the group, recognized other members as their peers, and made contributions to this group in different ways. To some extent, they built their affinity identity through the DCCE cohort.

In contrast, these teachers were *unable* to build their *institutional identity (i-identity)*. I-identity looks at the identity one has as determined by formal entitlements given by authority (e.g., myself as Human-centered Computing doctoral student, and my advisor as a Computing professor at Georgia Tech.) Under the current educational system, CS is excluded from the core curriculum of secondary education and there is no CS department that CS teachers can belong to. There is often no specific CS education certificate to entitle those who teach CS. Therefore, teachers lack the context(s) to develop an institutional identity as a CS teacher. They are unable to build an institutional identity as a CS teacher, and even could lose their commitment to teaching CS (as the case of Pat presents).

5.8.2 Identity development: CS teacher identity statuses

As presented in the above four cases, these four teachers had different self-identification and identity features over time. As Erikson and Marcia recommend (Erikson, 1956, 1968; Marcia, 1966), identity is not fixed but involves a process of exploration of and commitment to who one is. Therefore, one's sense of identity is determined largely by the choices and commitments made regarding certain personal and social traits. Marcia developed a framework for thinking about identity in terms of four identity statuses (Figure 5), which includes four possible statuses of identity: identity achieved, moratorium, foreclosed, and diffused (Marcia, 1966, 1980).

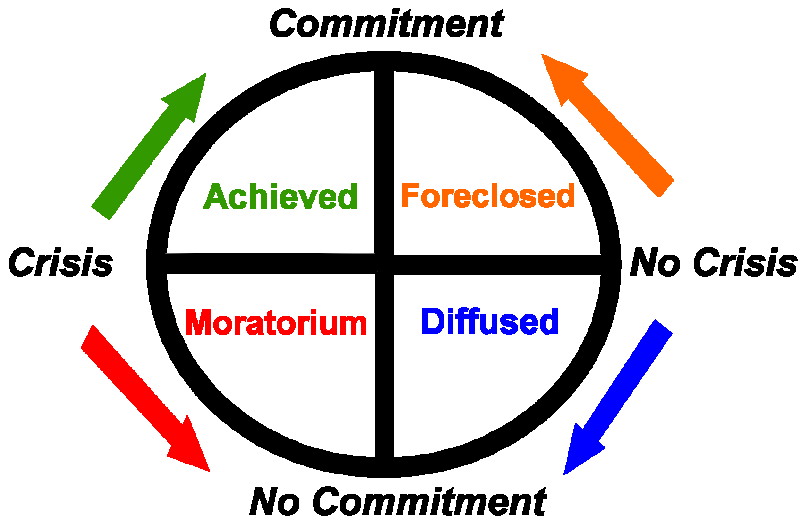


Figure 5: Marcia's Four Statuses of Identity

Identity achievement occurs when an individual has gone through an exploration of different identities and made a commitment to one. *Moratorium* is the status of a person who is actively involved in exploring different identities, but has not made a commitment. *Foreclosure* status is when a person has made a commitment without attempting identity exploration. *Identity diffusion* occurs when there is neither an identity crisis nor commitment.

Borrowing the identity development theory from Marcia to examine the statuses of the four participants' CS teacher identity, we can see that Cindy, John and Pat were at the *Moratorium status before the DCCE cohort.* After the DCCE cohort, these statuses have changed: Cindy and John have moved to the achieved status as a CS teacher, while Pat's identity is foreclosed. Meanwhile, Ryan had achieved his identity as a CS teacher before the DCCE cohort and stays the same afterwards. Figure 6 summarizes both of their previous and current statuses of the four teachers' identity.

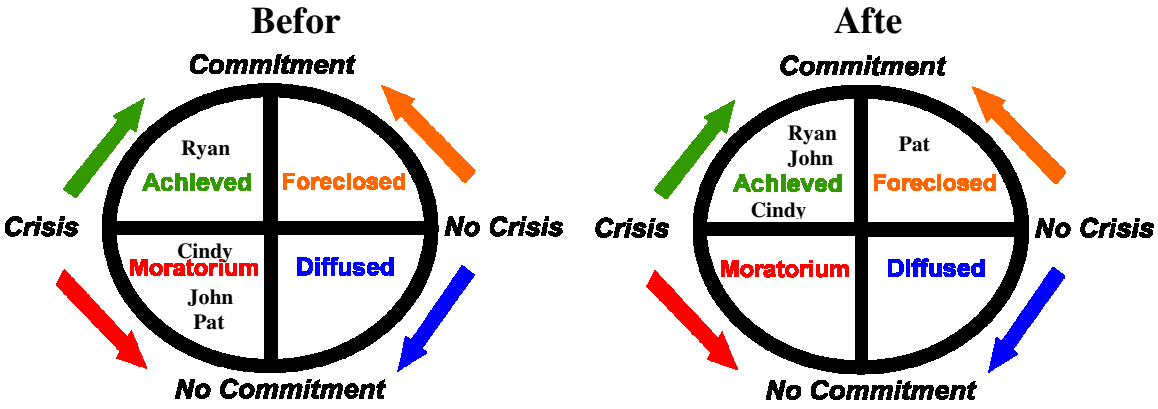


Figure 6: Statuses of Identity before DCCE and after

- **Cindy: Achieved Math and CS teacher**

Before the DCCE cohort, Cindy was at the moratorium status as a CS teacher since she was exploring her opportunities of teaching CS. She was interested in teaching CS, but felt less confident than teaching Math. Meanwhile, she was committed to teaching Math with her background and certificate in Math Education. Over the past 1.5 years, she has learned from the DCCE cohort and is growing into a CS teacher leader. Now, she feels more confident and enjoys teaching CS more. She also has significantly grown her CS classes into bigger size this year. She is planning to continue recruitment for CS in the future to be able to continue to teach CS. However, she still keeps her commitment to Math education for job security at the same time. Therefore, both of her identity as a CS teacher and the identity as a Math teacher are *achieved*.

- **John: Moving to identity achievement**

John's story presents an example of achieved CS teacher identity, who explored alternatives (e.g., being a Math teacher) and has deliberately chosen a specific identity (as

a CS teacher). He was probably at the moratorium status before the DCCE cohort, exploring his own commitment in Math and CS. Currently, he is confident in his teaching and also strongly committed to teaching CS. He has explicitly expressed that he would be devoting efforts to keep himself teaching CS, including continuing recruitment and possibly moving to another school where allows him to teach CS once the current school decides to put him back to more Math teaching load. Therefore, he is different from Cindy that he does not give commitment to Math teaching.

- **Pat: Moving to identity foreclosure**

Pat's identity as a CS teacher was actually weakened or lost to some extent. She had been very interesting in teaching CS before, and had learned to survive the first year of teaching AP CS with the help of the DCCE cohort. However, the RIF decision greatly hurt her feeling, and she was very disappointed with the current administration which did not value her teaching in CS. So, she ended up giving up her commitment in CS. Even if she was rehired later as a CS teacher, she is not comfortable with putting the hat of CS teacher on herself. She leaves the administration to decide her identity: Whatever they assign her to teach in the future, she would teach, not necessarily CS. She even prefers to teach Business if she had choice. Thus, her current identity can be seen more on the status of "Foreclosure" for CS since she leaves her identity to be determined by others (the administrators) instead of through her own exploration.

- **Ryan: Staying at identity achievement**

Ryan was already a committed CS teacher before he attended the DCCE cohort. His identity as a CS teacher has remained constant over time.

Gee's and Marcia's identity theories offer different lenses to help us understand these four teachers' identity features and identity development. As discussed above, these four cases present different examples of identity statuses and changes that happened among these teachers. Over the past 1.5 years with the DCCE cohort, these teachers were able to develop a sense of their affinity identity with a group of CS teachers, while they were unable to build their institutional identity as a CS teacher. One of the teachers, Ryan, has already built a sense of identity as a CS teacher and stays the same after the DCCE cohort. Cindy and John have both moved from the moratorium status to identity achieved, while Cindy keeps her Math teacher identity at the same time. Pat gives us a different case of developing CS teacher identity, moving from moratorium to foreclosure for building her CS teacher identity.

The next section discusses potential affordances of the DCCE program for these teachers' learning and identity development: in what ways has the DCCE program contributed to the development of these teachers' (affinity) identity and the change in their identity statuses as a CS teacher?

5.9 DCCE Affordances for Identity Development and Learning

The DCCE teacher cohort didn't change the four high school teachers' perceptions in terms of their own definition and values of CS. As discussed in study 1, these teachers already had an understanding about what is CS and the values of having students learning CS. All of these four teaches saw learning CS as learning problem-solving using computer, which was important and beneficial for students' success in the future. This kind of perceptions did not change overtime. For example, one of the teachers explicitly expressed that the DCCE experience did not change his views of CS.

[John]: "I'm not sure if DCCE did [change my views of CS], because again, that's something I've just thought about so much... I think that DCCE probably didn't affect that very much."

However, as summarized in Section 5.8, these four teachers had different self-identity statues and experienced different change trajectories. Meanwhile, they developed some sense of affinity identity (with this group of CS teachers). As proposed, the DCCE program was designed to support the participating teachers' identity development through facilitating community building and promoting reflection and learning among CS teachers. Figure 7 summarizes the findings from study 2, indicating how the DCCE program was able to support participating teachers' identity development through achieving these two goals.

In Figure 7, items on the left side (within pink boxes) present the main DCCE activities. The green box on the right outlines the different aspects of CS teacher identity. Emerged from data analysis, the themes in the middle yellow box with links to the different aspects of identity indicate potential ways that the DCCE activities might have offered for changing these teachers' sense of identity. Names on the arrows (change links) indicate those who have reported/indicated a particular impact. Here, solid arrows are used to present positive impacts, while dashed arrows are used for negative impacts. For example, both Cindy and Ryan reported that their good practices were affirmed through the sharing and reflection activities within the DCCE cohort, which helped them to gain confidence in teaching CS. However, the administrative decision had negative impact on Pat's commitment to teaching CS.

Section 5.9.1 and 5.9.2 further explain this influence pattern, presenting potential ways that the DCCE program might have contributions to the participating teachers' identity development through facilitating community building and promoting teacher reflection and learning.

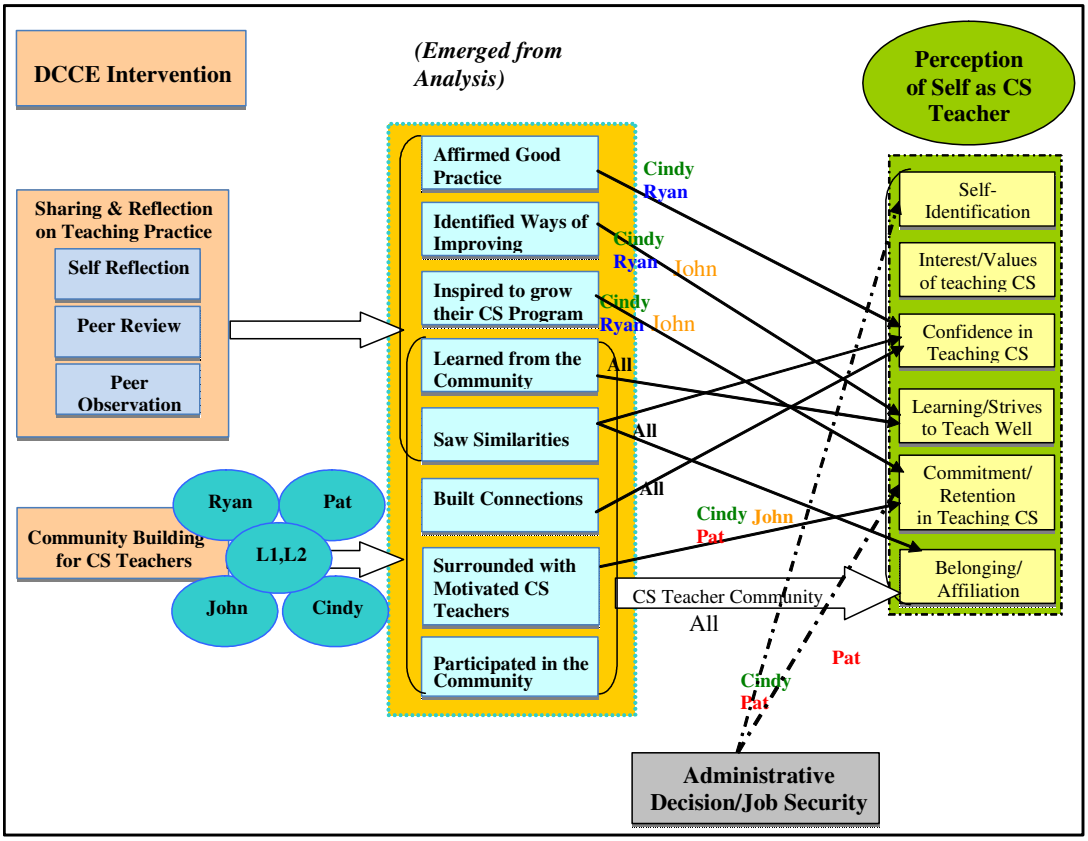


Figure 7: A Model of Supporting CS Teacher Identity Development

5.9.1 Facilitating community creation: Supporting affinity building

As we can see from the above sections, all the four teachers reported that they benefited from the DCCE CS teacher group. They were looking for peer CS teachers to connect before the DCCE cohort. In the DCCE cohort, they were **surrounded by motivated CS teachers**, and **saw** those teachers as their peer teachers with **similarities** among themselves and felt belonging to the DCCE teacher group. They were able to

build connections with other CS teachers in the DCCE. They all felt it beneficial to have these connections, which enabled them to **learn from the community** about new ways of teaching and identify good practices in their current teaching and ways of improving as well. These teachers **participated in this community in different ways**. A few of them were more focusing on sharing and learning from other members, and others started to make contributions back to the DCCE group and other local CS teacher communities by serving as a teacher leader and starting mentoring newer CS teachers. The DCCE cohort facilitated their community building and thereby supported affinity identity development through the following ways: gathering motivated CS teachers, supporting learning and connection building, enabling teachers to see similarities among themselves and participate in the community at different levels.

- **Gathering motivated CS teachers**

First, the DCCE cohort gathered motivated CS teachers who were teaching the same course. As discussed in Chapter 3 and Section 5.4-5.7, like many other CS teachers, these teachers were isolated before attending the DCCE cohort. They perceived teaching CS as difficult and challenging and were looking for peer CS teachers to connect and help with each other. They also saw many Business teachers who taught CS were not motivated and did not have the knowledge body and passion in teaching CS. Therefore, these four teachers really wanted to work with those who cared about teaching CS and would like to learn to improve their teaching. As John told us, they were able to find a community to join through the DCCE cohort.

[John]: "I felt like I didn't belong to a community at all of CS teachers until DCCE. But now I have a lot of teachers that I would feel fine about either calling

up or emailing. That did not exist before. That's one reason I think it's so important that we have things like DCCE, because CS teachers are usually pretty isolated in high school… I think in this group, the teachers were just so motivated. I guess that's partly why they were all there, a part of this group."

Surrounded with motivated peers in the DCCE cohort, they also got (further) motivated by each other. For example, Pat, who was the least experienced CS teacher in the group, felt a little uncomfortable with teaching AP CS when she came into the DCCE. However, she was encouraged and motivated by other teachers to continue to teach CS.

[Pat]: "The [DCCE] group, for me, was so helpful in solidifying or making me want to continue to teach in Computer Science, because it was a group where I could share a Computer Science question, an issue and how did you deal with this. We're on islands… So, what happens is you get stuck on this island, and you lose your motivation… The group has helped me enjoy computer science, see the value of it. I feel great about it."

- **Supporting connection building**

The DCCE program gathered these teachers together for a period of one year, providing a variety of activities for its participants to build connections. These teachers met every month face to face, reviewed and provided feedback to each other' course portfolio pieces regularly. They also went to another teacher's classroom to observe teaching and were observed by another teacher. Through these activities, the participants were able to understand the fundamental aspects of each other's teaching life, such as their teaching contexts and constraints, teaching methods and teaching philosophy, etc. They were able to know each other well enough to identify how they are similar to each

other. Also, they were able to see the differences among themselves and to understand why they were different. As we can see in earlier sub-sections, all of these four teachers reported that they had built connections with other CS teachers through the DCCE cohort and felt this kind of connection as very valuable.

Similar to the post-DCCE reports, data collected during their participation also indicated that these teachers were able to identify ideas to collaborate within the DCCE cohort. For example, through the portfolio review, participants proposed collaboration ideas in their comments. Here is one example:

> *[Ryan commented on Pat's writing about using concept map as an assessment tool]: "You are talking about having students create and represent their own thinking and modeling. That is where I am most excited about your imaginings – Inspiration, Mindview, Openview, Publisher, are all tools I am familiar with for that… [I] would love to collaborate about a few topics such as this one to use in our classes."*

- **Enabling teachers to see similarities among themselves**

As mentioned earlier, the continual, structured DCCE activities enabled the participants to get to know each other's teaching very well. They were teaching the same course in the same state. In spite of differences, they were able to see how similar they were in terms of teaching philosophy, teaching styles, challenges they were facing, questions they had, etc. For example, after the DCCE cohort, Cindy reported that she could see similarities between herself and each of the rest of the HS teacher participants.

> *[Cindy]: "Ryan kept saying, 'Jeez. It sounds like we teach very similarly.' So, even though he has got that whole, 'I disregard grades,' kind of thing, we take the*

same approach to our lessons as far as trying to get the kids to come about their own solutions… I think we all have a lot of things that are similar. You know, when I watched John, I think he and I had some similar styles, too, similar ways to approach things… The way that Pat has to approach her classes when she is, teaching two or three different types of classes all in the same classroom, that's a totally different picture, and naturally a different ballpark trying to balance all of those things together. But, I'm sure her and I have some similarities in how we approach things, too."

These teachers also made specific comments during their participation in terms of what they felt were similar to each other or they agreed with each other, such as the teaching philosophy they held, constraints they were encountered, specific methods they were using, etc. Taking Ryan as an example, he saw some pieces of Cindy's teaching philosophy were like his. For example,

[Cindy wrote]: "Every child can learn, but not every child can learn everything, nor should they want to… Never should student minds to be considered containers to be filled up with knowledge, rather knowledge should be cultivated and grown. As educators I believe our primary objective is to facilitate learning for students." [Ryan commented]: "I too like to provide space to students to choose their investment, prioritize their work, and follow their passions… I want to quote this for my philosophy too."

Similarly, Ryan expressed his understanding about the limitations brought by the AP test in assessment, responding to what Pat was struggling with.

[Pat wrote]: "My teaching philosophy drives me to choose creative approaches to assessment… Projects that really require high levels of critical thinking and collaboration are what I prefer. With the constraint of the [AP] test itself and the fact that the students actually must take a formatted test, I am somewhat limited."

[Ryan commented]: "I understand that tension. It is what led me to attempt to ignore the formal criteria and test-taking environment for awhile. I am now trying to reintegrate the focus on the test with my preferences for open-ended assignments."

Furthermore, in reviewing other teachers' portfolio, Ryan identified or expressed interest in some ideas/approaches mentioned or used by other teachers. For example, when Pat mentioned she saw paper and pencil review as an effective tool for assessing students' code comprehension and was planning to incorporate next semester, Ryan echoed with suggestions:

[Ryan commented]: "I also need to do this more. As we have all observed that we want students to be able to decipher other algorithms and code, this makes perfect sense as an integrated approach. This can be facilitated by reviewing as a class a whole how to edit or restructure the style and syntax and documentation of existing projects – both good and bad ones—before they work on each others' code."

- **Allowing participation in different ways**

In the DCCE cohort, the participants participated in different ways. As the one with least experience in teaching AP CS, Pat was mainly engaging in learning from other teachers. Ryan was moving from seeing himself different from others towards to feeling

belonging and having a professional voice in the group. Cindy and John were engaged in sharing with other teachers and looking for ways to improve their teaching.

Furthermore, their participation was continual after the DCCE cohort. All the participants would like to continue to connect with some of the other participants after the DCCE cohort. They saw the benefits of connection in promoting learning. For example, Pat was planning to keep connecting with the other teachers, and Cindy was serving the CSTA GA chapter to extend her connection.

> *[Pat]: "What was most influenced by the other members is the desire for colleagues in the field… From a connection perspective, that was strength. Because connected from a collaboration perspective, lots of similarities as far as what we teach, or how we teach it, why we want to teach it. Yet, there are some differences to learn from and to think, 'Oh, maybe I should think a different way.' You know, I could go through every single member and say I got something from each of them to take away… I think you probably sensed it in our last meeting. A few of us are fearful that we're not going to have this next year, and we're going to fall right back into where we were. So, therefore, what I got away from it every month was huge. Obviously, I keep in touch with most of the folks."*
>
> *[Cindy]: "I don't think I'd be doing CSTA with [the HS teacher leader] if it wasn't for this experience. I'll continue to collaborate with [L1]."*

5.9.2 Promoting reflection and learning: Enabling change and confidence building

Overall, the designed DCCE activities (such as continual discussion, documenting teaching, peer-review and peer-observation) were intended to promote teacher reflection and learning as a community. Achieved reflection and learning enabled teachers to

affirm good teaching practices, identify ways of improving their teaching, **get inspired to grow the CS program, and see similarities among themselves**. These affordances allow the teachers to increase their sense of confidence in teaching CS, learning to teach well and even strengthen their commitment to CS teaching.

- **Promoting reflection**

The course portfolio model was adopted to drive teacher reflection and learning. Evaluation results from the DCCE project show that it has successfully achieved this goal. Specifically for the four HS teacher participants, they were also able to see the primary benefit of the portfolios in aiding reflection on their own teaching. First, they found that the carefully designed process of portfolio production served a useful forcing function for driving reflection on their own teaching, which they did not always do before. For example, John and Pat similarly reported the portfolio was able to force them to reflect.

> *[John]: "I think all of these things [pieces of portfolios] just help teachers think more about what they do when they teach, and why they teach. I think that's something a lot of teachers don't really have the time to do unless they're forced to."*
>
> *[Pat]: "The portfolio, it was neat to reflect and go back through it, as hard as it was… So, the good from it was I could reflect back and I have a document now. But I ended up doing mine more of a reflection type thing. I mean, I put all the facts in there. 'Okay, here's how I do it." It was good to reflect on that. It was good to force me to say, 'How do I do this?'… It makes you have to think. It*

forces you to do that. That's a good thing. We don't always take that time to do it as teachers. We don't ever look back on what was good and what wasn't."

Furthermore, the course portfolio also provided a structure for guiding reflection. The structure of the course portfolio with well-designed guiding questions allowed teachers to see the structure of their course and examine the rationale and ways of improving the teaching of that course.

[Cindy]: "[What I Learned] through creating the course portfolio is reflection on my teaching. I learned a ton. It helped me to examine my own structure of the course. It made me question the order that I teach things in when I looked at the order that other people taught things in, my instructional presentation of it. I mean, it's just kind of nice to be reflective and to put those kinds of things on paper and to say, 'Okay. This really is truly how I do it.' Then to kind of ask yourself, 'Is it working the way that I do it, or is something that somebody else is doing working better?' So, I love those processes where they get you thinking about what you're doing and how you can improve."

Their experience in creating a course portfolio during the DCCE cohort also enabled them to conduct self-reflection after the DCCE project.

[Pat]: "As future plans for professional growth, I think [I would] just take time to sit down and reflect on what I've done, which DCCE has helped me do."

- **Affirming good practices and seeing similarities: Building confidence**

Through the process of peer observation and peer review, participants were able to not only see others' teaching, but also receive feedback from each other about their own teaching. Thus, good practices were affirmed. The teachers were encouraged and felt

confident. Meanwhile, they were also able to identify where needed improvement and find where to incorporate what they learned from other members.

> *[Ryan]: "I guess I was very surprised at how excited John was about his observation of my class. I didn't feel it was that exceptional a job. But somehow the questioning process and brainstorming discussions seemed to really be inspiring to him. I realized it's something I need to focus on more than I already do, because it has a potential. I guess I felt affirmed in a way I had never felt before. I felt that there's a place for my approach and I could incorporate some of those strengths that other teachers were bringing. I felt affirmed for having some of the ideas I had. So, I did leave with more confidence than when I came in."*

Also, as discussed earlier, participating in this CS specific community allowed the teachers to see the similarities in their teaching. Being able to see the similarities ensured their teaching and thereby made them feel more confident as CS teachers.

> *[Cindy]: "I think we all have a lot of things that are similar. When I watched John, I think he and I had some similar styles, similar ways to approach things. It's reassuring to watch him because it makes me feel like, 'Yeah. I'm doing it right.' I'm more confident hearing other people are doing it similarly. That gives you confidence when you don't teach it in a vacuum."*

- **Enabling teachers to see the diversification and identify ways of improving teaching: Motivated and inspired to learn to teach well/better**

Communication with different CS teachers of different backgrounds and teaching contexts offered opportunities for these teachers to see the diversification of teaching in

CS. They saw different teaching constraints from local contexts, different teaching techniques by different teachers, different goals and methods used at the college level and high school classrooms. Seeing the difference offered the openness of perspectives and methods, and also allowed the teachers to consider new ideas to teach and improve the way they were currently teaching. For example, John saw that DCCE gave him new ideas.

> *[John]: "It just gave me some new ideas and let me see how varied the teacher's perspectives were."*

Similarly, Pat believed that seeing the differences drove her to think differently.

> *[Pat]: "Yet, there are some differences to learn from and to think, 'Oh, maybe I should think a different way.' You know, I could go through every single member and say I got something from each of them to take away, either from a motivator of me as a teacher, or for content, or from, 'Ooh, that's an interesting way to think about it. Don't get stuck in this rut.'"*

These teachers reported their DCCE experience motivated them to make changes, in particular, through seeing and learning what other teachers did in their teaching practices.

> *[John]: "After seeing Ryan teach, I realized that there were definitely a lot of things I could do in my own teaching to improve. It really inspired me a lot and made me realize I've got a lot of room for improvement… I definitely have a lot of plans of how I will do things differently. I think a lot of them are a direct result of*

[the DCCE]. A lot of them directly come from conversations I had with teachers at DCCE."

Through interactions with other participants, they identified ways of improving their teaching by changing what they were currently doing. For example, John had already made some changes during his participation in the DCCE cohort and planned to extend those changes in the future.

[John]: "As far as the sessions go, I'll probably give students a lot more free responses, and I'll use rubrics that [L1] wanted to… That actually affected this past year of teaching. I created about eight rubrics… So, I will use those for next year, and I plan on creating more of them that are simulated to look just like the AP exam graders, how they grade their AP exams."

They also reported different ideas to improve their teaching after the DCCE cohort, such as changing their pedagogy to have more focus on problem-solving, to implement more discovery learning, and to introduce an IDE earlier. Here is one example from Cindy, who made many plans to change right after the DCCE. By the time she was interviewed again (six months later), she did reported that she was currently implementing these changes.

[Cindy]: "There are a lot of ideas that were shared that I will implement next year, you know, doing more hands-on things, some more discovery things like Ryan had mentioned, doing tests more like GridWorld test that John had shared. He shared a great one that's just less multiple-choice and more short answer. Then [I] have to do more problem-solving that way."

- **Inspiring teachers to recruit students and grow the CS program: Continuing teaching CS**

After seeing how other teachers were able to recruit students for CS, they were also motivated to consider growing their own CS programs. Also, they learned techniques of recruitment from other participants. Especially, Cindy and John got inspired by how L1 was able to recruit more girls into the AP class. They also got more ideas for recruitment through discussions in the DCCE meetings. Both of them significantly grew their programs over the past year. As Cindy's administrator (A1) was saying, although they were always motivated to recruit students, but the DCCE cohort drove them to take the action to recruit and finally successfully increase the student number in the CS classes.

> *[A1]: "I really think that a lot of the exposure from the [DCCE] has done that. We all have always talked about how many boys are in Computer Programming. Cindy and I talked for a couple of years about that. We just wished that we had more girls… Like I said, we talked about it some, but I don't think we put as much into action the first couple of years. Then this last year, I think just some ideas that she may have gotten from other teachers that she met through the [DCCE]. Just the interaction you get with all those people. She took a lot of the ideas and either changed them and tweaked or used them straight up. I just think she got a lot from talking to other teachers and hearing how other teachers had success."*

Another participant, Ryan, was also inspired by discussions about recruitment during the DCCE meetings. In respond to Pat's reflection on her own recruitment

strategies, Ryan expressed that he was encouraged to expand his recruitment strategies as a result of the discussion in the DCCE meetings.

> *[Pat wrote]: "I am working hard to grow the program at [my school] through beginning recruiting methods, starting the CATS (Computer And Technology Solutions) Club, taking as much additional training as I can find and afford, and by raising awareness of the need for computer science and technology in all future careers. I am also working with our Magnet School coordinator in recruiting magnet students to look at taking AP Computer Science since it is an additional AP course that requires no prior programming experience."*
>
> *[Ryan commented]: "You are wise to recruit from a variety of sources. I have typically simply wanted to invite others, offer the courses and see who genuinely wants to join them… As a result of our discussions at DCCE, I am gaining energy for more direct marketing, recruiting allies and the recruitment process and promoting CS more unabashedly."*

After seeing what Cindy and John did to successfully grow their CS classes. Ryan explicitly expressed that he was planning to try more active recruitment in his school for a future year.

> *[Ryan]: "What I'm hearing through some of the colleague discussions this year, is that they're able to offer a first experience in Computer Science as the AP with some success, and that they're able to push and pull to get students to join. They see nothing wrong with doing that. So, what I'm really doing is trying on a different personality mode to see if, 'Okay. Maybe if I act like a recruiter or if I do a little more pushing and prodding, that I can grow the numbers.'"*

5.9.3 Summary of DCCE impact: A change model

The above two sections presented a potential model of supporting CS teachers' identity development through prompting community building and teacher reflection and learning. As showed in Figure 7, through the DCCE program, participants were able to affirm their own good practices, see similarities among each other's teaching, identify ways of improving and also get inspired to grow their CS programs. These affordances supported their identity development as CS teachers by helping them become more confident in teaching CS, get encouraged and inspired to learn to teach better, as well as to become more committed to teaching CS. Meanwhile, they were able to build a sense of belonging to a group of CS teachers after actively participating in this community. In this group, they were able to build connections with other motivated CS teachers, see similarity among themselves and learn from each other as peers.

5.10 Summary of Chapter 5

This Chapter presents overall findings from study 2, focusing on the four high school teachers' identity development as a CS teacher throughout the DCCE cohort. These four cases provide different stories of these four teachers' identity development. Overall, the DCCE cohort enabled these teachers to build a sense of affinity identity within a group of CS teachers. These teachers were able to find peers to connect and collaborate through the DCCE cohort. A few of them even started to serve or planned to serve the community as a teacher leader. All of these teachers were able to gain confidence and ideas for improvement in teaching CS through learning and sharing their own teaching practices, seeing the similarities and differences among the group.

Through supporting community building and promoting reflection and learning, the DCCE program provided an inviting and open context for these teachers to explore their identity and achieve a sense of identity as a CS teacher. On the contrary, the sad story from one participant implies that administrative decisions that did not value CS teaching could hurt a motivated teacher and even lose her commitment to teaching CS.

CHAPTER VI CONCLUSIONS AND DISCUSSION

In this chapter, I will revisit and extend some of the results presented throughout the dissertation. I first examine the overall findings, and then turn to a discussion of the potential contributions made by this work. I will then reflect on the ways that DCCE as a professional development program specifically for CS teachers were able to and unable to make contributions in supporting CS teachers. I will discuss some unique challenges for studying CS teachers under current educational systems, followed by a few recommendations for CS teacher professional development. In the final section, I will elaborate on possible future research directions that stem from the work presented here.

6.1 Summary of Studies

My research centers upon understanding and supporting secondary CS teachers' professional identity and identity development throughout two studies. With this dissertation, I have investigated the perceptions that current secondary CS teachers hold and how to support their identity development through a professional development program focusing on community building and teacher reflection.

This thesis focuses on three research questions regarding secondary CS teachers' sense of identity:

- RQ1: What kind of professional identities do secondary CS teachers bring into their teaching practice?
- RQ2: What influences teachers' sense of identity as a CS teacher?

- RQ3: How does the participation with a focus on reflection within a local CS teachers' community (DCCE) influence CS teachers' perception of their professional identity?

The results presented in the previous chapters provide concrete answers to the research questions put forward in the introduction.

6.1.1 Understanding CS teachers' perceptions of professional identity

Study 1 presented in Chapter 3 spoke to RQ1 and RQ2. In particular, this qualitative study with current secondary CS teachers enabled me to explore how the teachers teaching CS courses saw themselves as what kind of teachers under the current educational system and what contributed to these perceptions. First, findings from this study offer examples of different self-identification and identity features for those teachers who saw themselves as a CS teacher, as a Business teacher, or as a teacher in both CS and another subject. Overall, a sense of identity as a CS teacher was not guaranteed among the teachers who were currently teaching CS courses. Many of them did not see themselves as CS teachers. All these teachers in this study felt isolated and the lack of peers and community. A few of them either were not committed to CS teaching or did not feel confident in their own teaching. Some of these teachers also held biased opinions about the subject they were teaching and who they should teach.

These results indicate that developing a sense of teacher identity can be a big challenge for current CS teachers. Putting them in the CS teaching profession does not guarantee a strong identity as a CS teacher in the teacher's heart. Such perceptions can also influence other aspects of their teaching life, such as their commitment to CS teaching, their willingness of striving to teach well, etc. As suggested by teacher identity

literature, their sense of identity and related perceptions can further influence how they perform in their teaching practices. For example, without a strong sense of CS teacher identity, a teacher could easily give up or put little efforts to sustaining her teaching of CS courses (e.g., not working hard for recruitment or learning new materials).

Second, four major factors were identified as the factors that contributed to these teachers' perceptions about their own teacher identity related to CS teaching:

- teachers' educational background and certification,
- CS curriculum and department hierarchy,
- the availability of CS teacher community,
- and teachers' perceptions about the field of CS.

Teachers in this study perceived that the lack of educational background in computing and CS teaching certificate, as well as the computing curriculum and school hierarchy under the current educational system prevented them from building a sense of identity as a CS teacher. In addition to these political/policy aspects of CS education, these teachers' perceptions of the CS field and the isolation of themselves also put them in a difficult situation for identifying themselves as a CS teacher. Peer support was not available for these CS teachers, while teachers in other subjects were easy to access through their local departments. These teachers also held different perceptions of the field, and thereby felt differently about their teaching, such as their confidence in teaching CS, their sense of the need of learning and what kind of community they belonged to.

One important takeaway from these findings is that we really need a better administration system for secondary CS education with a consistent certificate standard for CS teaching and a curriculum that values CS as core. Without these forms of

administrative support, the impact of efforts in preparing and sustaining quality CS teachers will be greatly weakened. Another takeaway is that most current CS teachers are isolated and in need of connection and community to support each other and stay in the profession as qualified teachers. If we want to sustain those good teachers we have recruited and trained, we need to offer continual support for them along their teaching.

6.1.2 Supporting CS teacher identity development

Study 2 presented in Chapter 5 outlined the results pertaining to RQ3. These four cases in study 2 presented different examples of identity statuses and changes that happened through their participation in the DCCE teacher cohort. As presented in Chapter 4, the DCCE program was designed to support the participating teachers' identity development through facilitating community building and promoting reflection and learning among CS teachers. My overall results indicate that these study participants were able to develop a sense of affinity identity with a group of CS teachers, while they were unable to build their institutional identity as a CS teacher under the current educational system. These four teachers also experienced different self-identity statuses and change trajectories.

Results from this study indicate a potential model of supporting CS teacher identity development through facilitating community building and promoting reflection and learning among those participating teachers (summarized in Figure 7). The DCCE program provided an inviting context for these teachers to explore their identity and achieve a sense of identity as a CS teacher. Participants were able to affirm their own good practices, see similarities among each other's teaching, identify ways of improving and get inspired to grow their CS programs. These affordances supported their identity

development as CS teachers by helping them become more confident in teaching CS, get encouraged and inspired to learn to teach better, as well as become more committed to teaching CS. Meanwhile, they were able to build a sense of belonging to a group of CS teachers after actively participating in this community. In this group, they were able to build connections with other motivated CS teachers, see similarities among themselves and learn from each other as peers. On the contrary, the story of one participant (Pat) implies that administrative decisions that do not value CS teaching can hurt a motivated teacher and even cause the loss of her commitment to teaching CS.

Study 2 has showed that it is possible to design and implement a professional development program to support CS teachers in building a sense of community and learning through a community of practice. These results also confirmed that the use of the DCCE program in promoting community building and teacher learning can have an impact on secondary CS teachers' identity development (and thereby help them become committed, qualified CS teachers). As a first attempt at supporting current CS teachers, these findings are encouraging.

6.2 Contributions

In answering these research questions, this work makes several contributions to the computing education research community as well as to the teacher education community.

6.2.1 A new lens to examine the issues of preparing and supporting secondary CS teachers

First of all, this work offers new insights into the fundamental issues of preparing and supporting CS teachers, through using teacher identity as a new theoretical lens to

understand and address some essential challenges for building committed and qualified CS teachers. Applying the lens of teacher identity, the process of becoming a committed, qualified CS teacher is embedded with a process of developing a professional identity as CS teacher. Failing to develop a sense of CS teacher identity can lead to the failure of developing a qualified teacher who values, is capable of and committed to CS teaching.

Seeing teacher identity development as an essential process of ongoing situated learning, this work offers new focuses and approaches for understanding, influencing and assessing teacher learning within a community of computing educators. Informed by related theories about teacher identity development, the DCCE program supports teachers' identity development by offering opportunities for them to narrate, question, explain and revise their own beliefs and theories about CS teaching, through the process of creating and peer reviewing of course portfolios, peer observation and self-reflection on their teaching practices.

6.2.2 Theory of CS teacher identity and practice of promoting CS teacher identity development

By focusing on the perceptions of teacher identity from a group of CS teachers, this work also contributes to the theory of teacher identity and the practice of promoting teacher identity development overall. As an initial study on CS teachers, this work (as summarized in Section 6.1), provides a rich description of how current CS teachers see themselves in their teaching profession. Meanwhile, it also presents empirical evidence for effective ways of engaging and influencing CS teachers' identity development.

6.2.3 Identifying some unique challenges of developing CS teacher identity

Teacher identity can be a general property for qualified teachers in any subject. This work reveals some unique challenges for in-service CS teachers to develop a sense of identity. Most work on teacher identity focus on pre-service teachers and beginning teachers, or career changers, who are transferring their identity from a dramatically different role (e.g., a student or student teacher, a non-teaching profession) to the role of being a new teacher (Beijaard, et al., 2004; Jeanne M Grier & Johnston, 2009; Volkmann & Anderson, 1998). However, it is still a particular issue for in-service CS teachers even with years of teaching experiences. This work identifies two unique contexts that make the issue of CS teacher identity pronounced.

First, as discussed in earlier chapters, the structural or policy framework of computing education prevents current CS teachers building their sense of identity. Unlike subjects under core curriculum, the current educational systems are unable to provide the social/administrative context for CS teachers to develop their teacher identity in CS. Lacking computing background, CS teaching certificate and specific CS department, with computing education usually unvalued by the administration and possibly the broader community as well (e.g., parents and students), it is difficult for teachers to identify themselves and make commitment to the identity as CS teachers. As reported in the results of this work, a teacher with a Math background can easily attribute herself to a Math teacher identity. Similarly, a Business teacher certified in Business Education naturally sees herself as a Business teacher. However, what makes a teacher identify herself as a CS teacher?

Second, the field of CS itself also brings its own unique issues to CS teacher identity. The relatively newness and evolving nature of computing as an academic field has its own problem of defining its content and scope. There are still deep and widespread confusions as to what should constitute and how to differentiate computer science and other uses of computing technology within education. Thus, it is difficult for teachers to identify the subject itself and its values as well as the target students they should serve, good practices for teaching this subject, etc. Meanwhile, as found in this work, teachers are also encountered with difficulties in finding peer teachers who value and understand CS teaching.

In summary, HS CS teachers are facing some unique challenges in building their own sense of identity, which are greatly influenced by the social, cultural and technical systems surrounded with them. This work is not intended and by no means able to address all of these issues. Instead, it brings forward these issues and discusses how these issues might bring unique challenges for preparing and support secondary CS teachers. The next section will discuss in what ways DCCE as a PD program can and can not offer support for current HS CS teachers.

6.3 Reflection on DCCE as a Professional Development Program for CS Teachers

Section 6.1.2 has summarized the ways that DCCE supported current CS teachers in developing a sense of professional identity as CS teachers. In this section, from a CS teacher educator' eyes, I reflected on the ways in which DCCE was both successful and less successful as a professional development for CS teachers. I then extend this

discussion in the next two sections by offering suggestions for designing CS teacher professional development programs and discuss future research directions.

6.3.1 What worked and what made it work in DCCE?

Findings from study 2 have suggested that DCCE was successful in addressing the issue of teacher isolation and supporting CS teachers building their affinity identity. Meanwhile, DCCE also helped teachers build confidence and commitment to CS teaching. In addition to identity development, reports from the DCCE participants also indicated another two positive results from this program: creating local CS teacher leaders and growing the CS programs in participants' local schools.

- Growing CS programs in participants' schools

In addition to building their sense of identity as CS teachers, anecdotal data from the past two DCCE teacher cohorts indicate that many of these participants have significantly increased the numbers of AP CS students after their participation in DCCE.

Table 16: Number of AP CS Students from the Four Participants

Participant	Number of AP CS Students	
	2009-2010 (Year of DCCE)	2010-2011 (Post-DCCE)
Cindy	8	55
John	24	69
Pat	7	40
Ryan	10	7

Table 16 lists the number of AP CS students from the four teachers in study 2, during the year of DCCE and the year after. Ryan, the private school teacher, was the only participant who did not increase the number of students in his AP CS class. However, he did recruit more (from 17 to 23) students into his intro programming course

in Java, which was a prerequisite for AP CS in his school. Moreover, Cindy successfully recruited two full sessions of beginning programming students in 2010-2011. Some of them also reported good student performance in the AP CS exam.

- Developing local CS teacher leaders

On one hand, DCCE developed its own teacher leaders from the first year cohort serving for the second and third cohorts. In addition to helping us running the second DCCE cohort, they also hosted the third cohort which only invited HS AP CS teachers. On the other hand, participants from the first and second year DCCE cohorts have being playing leading roles in more local communities, including the CSTA Georgia Chapter and CS teacher groups in their local counties.

Reflecting on how DCCE was able to achieve its goals of supporting in-service CS teacher learning, I see a few features of the DCCE program as key for success.

- Sharing among CS teachers

It seems straightforward that professional development programs should allow teachers to share with each other what they are doing. In reality, there are not many professional development programs available for CS teachers and not all of these programs focus on sharing ideas and experiences among teachers. DCCE explicitly asked teachers to share their practices through multiple ways and offered a structure supporting their sharing by creating course portfolios and observing teaching.

- Observing other teachers

Peer observation was reported as one of the most beneficial activities by the participants. It offers opportunities of learning for both the observer and the observee. Peer observation can get teachers to see how other teachers are doing in their classrooms,

as well as help them reflect on their own teaching. By allowing newer CS teachers to observe or be observed by master teachers, peer observation also provides a way of mentoring.

- Master teachers serving as facilitators

Observations from the DCCE program also suggest that teacher leaders can play significant roles in achieving the goals of building community and promoting reflection. Teacher leaders can bring insights into the group of CS teachers with their passion in computing education. As peer teachers, the leaders can show understanding and emotional support to other teachers, as well as serve as a master role for the development of the community. Meanwhile, teacher leaders can also provide a role model for other teachers. As discussed before, our CS teachers might be intimated in sharing their teaching without formal training in computing and computing education. They usually do not participate in professional communities for CS teachers as teachers of other subjects do. However, through programs like DCCE, they can learn how to participate in and facilitate conversations with other CS teachers in a professional way by observing these teacher leaders. They also gain confidence about their own teaching through their participation in the program, which encourage them to serve as teacher leaders for newer teachers.

6.3.2 What did not work? Challenges and limitations

- Institutional identity and external factors

Under the current educational system, teachers lack the context(s) to develop the institutional identity as CS teachers. They are unable to build an institutional identity as a CS teacher. Findings both from study 1 and from the case of Pat in study 2 indicated that

external factors such as the structural contexts of computing education (its curriculum and school hierarchy, teacher certification policy) and administrative decisions can be significant. DCCE supported the participants in building affinity identity as a CS teacher, which helped to overcome some tensions from the lack of institutional identity. All these participants became more confident, felt inspired and motivated in teaching CS. However, the case of Pat indicated that affinity identity as a CS teacher can be trumped by the lack of institutional identity.

Changing those structural contexts of computing education is hard to be achieved simply through professional development programs like DCCE, DCCE is limited in terms of changing those structural aspects. DCCE brings forward these issues that CS teachers are encountered, offering opportunities for teachers to share the tensions and understand these issues. Hopefully these teachers can get motivated to support and collaborate with researchers and administrators to address these issues eventually.

- The cost of DCCE

As discussed in Chapter 4, DCCE is an expensive model for professional development. First, it is expensive for teachers to travel to meet every month. DCCE is lucky to have NSF funding for participant support, which covers the travel and other costs of running these regular meetings. Without such funding support, it can be more difficult to recruit teachers to participate in this kind of programs. Second, DCCE also requires a big commitment from the participants. DCCE participants invest their time and energy in the DCCE activities over one year. Teachers have to spend their off-work time attending meetings and working on assignments after the meetings. This requirement can prevent many HS teachers with a heavy teaching load from participating in this program.

We have seen participant dropouts in all the past three cohorts. I will discuss a few ideas of addressing this limitation in Section 6.4 as one of the future research directions.

- Requirement of CS content knowledge

DCCE is aimed at supporting in-service CS teachers while not focusing on teaching basic CS content knowledge. However, it requires that participants are teaching a similar course and have at least some basic CS content knowledge for effective self-reflection and communication with other teachers. In fact, all the four HS participants in the second DCCE have already gained training in CS teaching by attending workshops offered by ICE and other organizations. Therefore, they probably have fewer struggles in computing content knowledge and have some fundamental knowledge of CS pedagogies than a brand new CS teacher. These teachers can have meaningful conversations reflecting on their own teaching and their own identity as a CS teacher. In DCCE, the teacher leaders can focus their mentoring more on pedagogy and high-level issues of computing education instead of specific computing content knowledge.

However, in the real world, we might have more new or beginning CS teachers with little content knowledge and CS teaching experience. Although DCCE can still help participating teachers learn content knowledge from each other, this is not its main goal. Work from the ICE and GaComputes suggests that teachers with little content knowledge can be too overwhelmed by learning programming content knowledge to consider pedagogies and other aspects of CS teaching. Ideally, the current DCCE program is not designed for helping these CS teachers.

6.4 Implications for CS Teacher Professional Development

In this section, I distill some takeaways for CS teacher educators who are dedicated to preparing and supporting secondary HS CS teachers, based on my observations in the DCCE program. Drawing directly from the findings of this work and the project evaluation of the DCCE program, I argue that it is a rewarding but complex process to design and implement a professional development program focusing on promoting community building and teacher reflection for CS teachers. I would make a few recommendations for researchers who are interested in designing and implementing such kind of programs.

- **Create commons among different teachers**

Current CS teachers may have different backgrounds and interests, teaching in different contexts. It is naturally for them to see how different they are from each other. To help these different teachers build connections and sense of affinity, it is critical to guide them to see the similarities among themselves. For example, teachers in the DCCE cohort were all teaching a common discipline: computing. More specifically, they all taught AP CS or undergraduate introductory programming. In addition to that, their willingness to attend the DCCE program also indicated they were all motivated teachers to some extent. Many of them were facing similar challenges or issues in their teaching, such as the lack of technical support, few female and minority students and varied levels of student ability. Working with teachers who are passionate about CS teaching and teach at the same level enables teachers to see the common ground for developing community (Wenger, 1998). Continual interactions with other teachers can also help them identify the similarities in details of their courses and practices. Meanwhile, as facilitators, we

should encourage our teachers to understand the differences among their teaching, but also take these differences to foster reflection on their own teaching choices and identify ways of improving. Understanding the commonality as well as the differences among each other can be a good start to build the sense of affinity and emotional support among the group of CS teachers.

- **Promote meaningful conversation: Get the teachers to talk**

To achieve the goal of building a community for CS teachers, I would argue that we need to ensure that our facilitation efforts help participants engage in meaningful sharing and reflective conversations. We need to let the teachers talk instead of merely listening to us (e.g., researchers, organizers, and teacher leaders). It is very likely that meaningful dialogues do not naturally occur in the first few meetings among the teachers while they are still exploring and trying to understand each other's teaching life. It is worthwhile to slow down the pace of the program and offer some scaffolding to moderate the conversations. We can encourage the teachers to open their mind and build an inviting and supportive environment where they are comfortable with sharing different sides of their teaching, listen to other teachers and provide sympathy and constructive feedback.

Findings from this work and the DCCE project evaluation also indicate that the course portfolio model including its peer-review and peer-observation mechanism is an effective strategy for structuring meetings and guiding conversations among the participants (Ni, Guzdial, Tew, Morrison, et al., 2011). The collaborative process of portfolio creation and peer review can force teachers to document, question and explain different aspects of their practices along with a group of peer CS teachers. Although these

activities require appropriated facilitation from teacher leaders and big time commitment from participants, they offer specific structures to guide effective reflection and meaningful conversations.

- **Use teacher language instead of research perspectives**

The observations from the DCCE program also suggest that using teacher language instead of research perspectives when communicating with our teachers. Some of our HS CS teachers can be still struggling with the content knowledge of computing, while some might be struggling with other challenges in their teaching. While these teachers are open to learn new knowledge and techniques, they might feel overwhelmed by research terms and perspectives they are not familiar with. In particular, having experienced teachers serving as facilitators can be very helpful in moderating conversations and translating research terms into languages understandable for our teachers. For example, as introduced in Chapter 4, the DCCE facilitators (teacher leaders) worked with the research team and developed worksheet style documents to guide the participants' reflective activities, such as the observation guideline, reflection log and specific writing instructions for each portfolio assignment.

6.5 Open Questions and Future Work

In this final section, I briefly explore four possible directions for future work that are relevant to supporting in-service HS CS teachers, while raising some open questions that are important but out of the scope of this thesis.

6.5.1 Expanding the studies

As a first thesis investigating the issue of CS teacher identity, this work offers an initial understanding of current CS teachers' perceptions and ways of supporting their

identity development. Studies in this work can be further expanded. First, results from study 1 can inform a future study with more CS teachers to better characterize CS teacher identity and potential influencing factors. For example, based on the findings from study 1, we can develop a CS teacher identity survey and deliver it to all the CS teachers in Georiga or even all the CSTA members nationally to gain further understanding for my first research questions (RQ1 and RQ2).

Second, study 2 can also be strengthened by following with those participants in a longer term. In addition, DCCE focuses on promoting affinity identity development to address the issue of teacher isolation. This work did not explicitly examine the discourse-identity of these teachers, such as the languages they use to talk about CS concepts to other teachers and the ways of presenting ideas. Studies that look closely at the discourse/languages in addition to the beliefs, perceptions (studied in this work) from these teachers, can offer further understanding of CS teacher identity.

Third, gender issue can be another factor to be examined that influence CS teacher identity and identity development. It is well known that gender is a big issue In computing education (e.g., fewer women students in CS, gender difference in CS learning and preconceptions of CS) (Misa, 2010; Zweben, 2011). This work did not particularly look at the gender issues amongst the teachers in the research agenda. The participants were overall gender-balanced (4 male and 5 female teachers in study 1, and 2 male and 2 female teachers in study 2). I did not observe much gender difference among the CS teachers both in their identity and their interaction in DCCE (e.g., who they collaborated with and respected more.) Samples in this work are very small. It is interesting to examine the gender issue among the CS teachers in a larger study.

6.5.2 Expanding DCCE for more in-service teachers

In this work, we have seen some successful evidence for supporting secondary CS teachers' identity development through a professional development program like DCCE. These participants have reported increased sense of community and confidence as well as commitment to CS teaching. Many of these participants have significantly increased the numbers of AP CS students after their participation in DCCE. It is also encouraging to see some of the DCCE participants are currently serving as leaders in local CS teacher communities. To some extent, DCCE is successful in fostering CS teachers and developing teacher leaders.

However, the previous DCCE program served a small group of local CS teachers, with around only a few (4-8) HS teachers each year. We have reached to a very small portion of the in-service CS teachers (compared to a total of 72 Georgian AP CS teachers in 2009). I would like to question: How can this kind of program benefit more CS teachers?

One possible way to expand the DCCE program for a broader audience is to *clone* more DCCE groups in local districts, led by local teacher leaders. Since we have developed a few teacher leaders from the past DCCE cohorts, these teachers can transfer the DCCE model to their local communities and serve local CS teachers. To relieve the stress of time commitment, it can be helpful to institutionize such kind of programs into local professional development requirements (e.g., making it part of the monthly professional development event in each county). On one hand, since professional development programs specifically for CS teachers are still rare, such kind of programs can benefit more CS teachers. On the other hand, with programs like DCCE being part of

regular teacher professional development, it can help to recruit participants and make it easy to arrange meetings and other activities.

6.5.3 Mentoring new CS teachers

.As mentioned in the first chapter, the computing community is dedicated to develop 10,000 CS teachers, while we have only around 2,000 of them currently. So, how can programs like DCCE also help those 8,000 new CS teachers, who might have less experience and less content knowledge of computing?

With possibly a big number of new CS teachers, it is especially needed to foster and sustain these new teachers. Literature on teacher induction and mentoring suggests that mentoring teachers who are new to the profession as an effective strategy for improving both new teachers' skills and the likelihood that they will stay in the profession (Curran & Goldrick, 2002; Scherer, 1999). A lot has been written about the merits of creating a community of support for new teachers in general, but little has been done for CS teachers. Therefore, another direction for future work can focus on adapting the DCCE program for newer CS teachers. There are many interesting questions to explore here. For example, what, if any, parts of the course portfolio model still work for these new CS teachers? Peer observation of classroom teaching was recognized as the most valuable activity by the DCCE participants. Can this be an effective mentoring component for new CS teachers? What kind of mentoring strategies from other subjects can be adapted for CS teachers? What is the best combination of teachers with different levels of experiences and content knowledge for building a vibrate community of CS teachers?

6.5.4 Moving DCCE to online communities

One big challenge of implementing the DCCE program is the requirement of teachers' time commitment. Participating CS teachers are required to devote a large amount of time in attending all the activities, such as traveling for monthly face-to-face meetings, reading related literature, regularly writing and reviewing portfolios, and visiting another teacher's classroom teaching. Although it is a rewarding experience for them, these teachers have to sacrifice their weekend time to attend the DCCE meetings. It is also financially expensive to support these meetings from the organizers. Another challenge for programs like DCCE is to sustain the current community while teachers are not regularly meeting face-to-face any more, after their initial participation in the one-year cohort. A follow-up evaluation with the first and second year DCCE participants indicates their desire to continue the connections built through DCCE, but most of these teachers can not afford for regular meetings for another year.

This dissertation did not particularly explore online communities for HS CS teachers. In the current DCCE program, social network sites (a ning[13] site for the first year, and a Google site for the second cohort[14] and third cohort[15]) were used mainly for resources sharing and documentation. We've seen some successful uses of online communities in supporting large groups of teachers' professional development, such as Tapped In[16], The Math Forum[17] and KNOW[18]. Creating or adopting online communities

---

[13] http://dccega.ning.com.
[14] https://sites.google.com/site/dcce2009.
[15] https://sites.google.com/site/dcce2010.
[16] http://tappedin.org.
[17] http://mathforum.org.

can be another future direction of extending the DCCE effort for supporting CS teachers. Here are some potential research questions: Can online communities attract a broader audience of CS teachers? What are the main activities that can support community building? Will the course portfolio model still work? What kinds of facilitation are required for active community participation of a bigger group of CS teachers? How can online community help to sustain current CS teacher communities in a longer term?

In summary, teacher identity is a relatively new concept for CS teacher education. There are many directions open to explore. This dissertation work provides an initial understanding of current CS teachers' professional identity and ways of supporting their identity development through professional development programs. My findings suggest guidelines for professional development program design and implementation for building committed, qualified CS teachers in ways that promote the development of CS teacher identity. More work on understanding teacher identity and supporting identity development can help to build qualified CS teachers in order to achieve quality CS education.

---

[18] http://know.umich.edu.

APPENDIX A STUDY 1 MATERIALS

This appendix contains materials needed for study described in Chapter 3.

A.1 Recruitment Text

Hello, my name is Lijun Ni, and I'm a PhD student at Georgia Tech, doing research on Computers Science Education. As part of my research, I am conducting a study of the practices of teachers who teach computer science courses. Specifically, I would like to visit several high school computer science teachers, especially those schools who have students taking AP computer science.

As a participant, you will complete a short demographic survey and take part in a face-to-face interview at your school about your teaching experiences. Completing the survey and the interview should take no longer than 90 minutes and can be scheduled at your convenience. Also, a visit to your classroom is optional, but will be helpful for my study if you are comfortable with that.

If you are interested in participating or having any questions about this study, please contact me by emailing to **lijun@cc.gatech.edu**.

Thanks a lot for your help!

Lijun Ni

A.2 Participant Background Survey

1. **Your name:**
2. **Email:**
3. **School:**
4. **What is your age?**
   - o 22-30 years
   - o 31-40 years
   - o 41-50 years
   - o 51-60 years
   - o 61+ years
5. **In your school, which department do you belong to?**
6. **How many students are enrolled in your school?**
   - o 1-100 students
   - o 101-250 students
   - o 251-500 students
   - o 501-1000 students
   - o 1001-2000 students
   - o 2001+ students
7. **Which of the following types of computer science courses are offered at your institution [select all that apply]?**
   - o Computing in the Modern World
   - o Beginning Programming
   - o Intermediate Programming
   - o CS AP A
   - o Other: _____
8. **In a typical year, how many students take AP CS in your school?**
   - o None
   - o 1-10 students
   - o 11-25 students
   - o 26-50 students
   - o 51-100 students
   - o 101+ students
9. **In a typical year, how many computer science courses do you teach?**

- None
- One
- Two or three
- Three to five
- More than five

10. Please list all the computer science courses you teach

11. Under what department is computer science courses offered in your school?

12. How many years have you been teaching at secondary level?

- One to five
- Six to ten
- More than ten

13. How many years have you been teaching computer science courses?

- Less than one year
- Two or three
- Three to five
- More than five

14. What kind of certification(s) do you hold?

15. Please list your prior education background, including any degree with major:

16. Please list primary professional development programs <u>related to computer science</u> you attended or are attending:

17. Please list primary professional development programs <u>NOT related to computer science</u> you attended or are attending:

18. Please list any professional organization/community you are currently attending at your local district/state and national level:

A.3 CS Teacher Identity Interview Protocol

Part 1.Opening Comments and Introduction

• Welcome and thank the participant.

• Introduce yourself, explain the purpose of this interview, and describe the interview process.

Part 2 Self-perception of Teacher Professional Identity

2.1 How would like to introduce yourself about what do you do to other teachers in an educational conference?

2.2 Please tell me the story of how you became a teacher and then started teaching computing?

- Your motivation: what drives to going into teaching? What made you start teaching computing course?
- School context: please describe your school conditions, such as student demography, teaching load, etc.

2.3 Can you explain what does teaching Computer Science mean to you?

- Your definition of computing/CS
  - How do you explain the definition of CS to your students?
  - How do you explain the definition of CS to the parents of your students?
  - How would you describe the definition of CS to your fellow teachers and administrators of your school?
- In your opinion, what are the values of learning computing?
  - What makes CS meaningful to you?
  - What makes CS meaningful to your students?
- Please tell me about the CS courses you are teaching:
  - Course names, students, section/schedule, etc.
  - What are your goals of the CS course (s)?
  - What do you expect student can get out of the class?
  - What content/standards do you teach?
  - What teaching methods do you use? Describe a typical lesson in your classroom.

- How does this CS course (these CS courses) fit into the school's curriculum?

- Tell me about how you feel about your CS teaching?
  - How do you feel about your own ability in teaching these courses?
  - How satisfied do you feel under your current teaching condition?
  - What is the biggest challenge that prevents you staying in teaching CS courses?
  - What are your overall plans for continuing your professional growth?
  - What would you do to improve your teaching?

2.4 For 2.1-2.4: what contribute to these perceptions? What make you think….?

Part 3 Community of Practice

3.1 **What do people in your school usually call you and view you as a teacher?** Your students, other teachers, principles, department chairs……E.g., what subject teacher does your principle/department chair view you primarily?

3.2 Communities/Organizations you participate(d)

- Explain the communities you list in the background survey: what kind of communities they are? What made you join those communities? What do you do in those there?
- If no CS (education) related community is listed (e.g., CSTA, CS teacher mailinglist), do you know any kind of those communities? If yes, what prevent your participation?

3.3 Where/whom do you usually seek support from if you have a question about your CS class?

3.4 How often do you discuss teaching with the following individuals:

- Other teachers in your department;
- Other teachers at your school outside your department;
- Staff at your school who specialize in teacher professional development;
- Teachers who teach similar courses as you at other schools;
- Teachers who do not teach similar courses at other schools;
- Computer science faculty at local institutions.

Part 4 Other comment/suggestions for us?

APPENDIX B SUPPORTING MATERIALS FOR DCCE

This section lists some examples of materials design(ed) to support our teacher participants' reflection activities.

B.1 An Example of DCCE Meeting Agendas

Meeting 6 (March 3, 2010)

Today's goals:

Through today's meeting, participants will be able to

1. describe different types of assessments used by the participants
2. describe the AP CS grading rubrics
3. develop an assessment chain (identify the link(s) from m grading rubrics to assessment questions and to learning objectives)

Agenda:

9:00-9:05 Today's agenda and goals

9:05-9:15 Touch base from last meeting

9:15-9:20 Round-robin discussion of the types of assessments brought to the meeting

9:20-10:20 Small groups - what do they assess?

Break into groups (labs, projects, tests) to determine what the assessments were designed to assess

10:20-10:30 Break

10:30-11:15 How AP questions are graded

11:15-11:45 Break into pairs to develop a rubric for one of the assessments in the group

11:45-12:00 Summarizing session - What did we learn

12:00-12:45 Working Lunch - Assessment Chain (Can you link from the rubric to the assessment question to the learning objective for the course?

12:45-1:00 Peer Evaluation Discussion/Session evaluation, looking forward to the next session

B.2 An Example of Course Portfolio Review Guideline

Subject: Teaching Context

As you read through other people's context portions of their portfolios, consider if the writer has answered the following questions:

Institutional context:

1. Do they explicitly state the institution at which they teach?
2. Do you understand the program/area in which they teach?
3. Are the constraints of the course well explained (number of students, hours of contact, flexibility
in selecting books, software, etc.)?
4. Is the typical student defined?
5. Where does the course fit into the overall program / area defined?

Course context:

1. What are the instructor's goals for the course?
2. What does the instructor want the students to learn and/or accomplish?
3. What skills and practices should the student acquire in the course?

Finally, WHAT EVIDENCE IS THERE THAT SUPPORTS THE ANSWERS TO THE ABOVE QUESTIONS?

Evidences (artifacts) are important as they support the writers' claims. Artifacts should be selected that support the statements, but that also show how the claims may affect the design and teaching of the course. They also reflect the instructor's personal beliefs and values about the course.

B.3 Guideline for Taking Peer Observation Notes

Peer Observation Notes

Instructor: _____ Observer:_____

Time and Place for the observation:
_____

Instructor's goals for the class being observed:

The instructor asks the observer to pay special attention to:

Observation Notes

1. What is the context of this observation?

   How is the classroom arranged?

   How are the students arranged?

   Noteworthy observations about environment

2. What is the content of this observation?

   What is the goal of this lecture/lesson?

   What has happened immediately prior to this lecture / lesson?

   How is the class time used?

3. What teaching methods are used during this observation?

   List each teaching method used along with its purpose during this lecture / lesson

   Comments on interesting uses of teaching methods, combinations, segue ways, etc.

4. Proof of student learning

   How does the instructor assess if/what the students are learning?

What observations can be made about student learning?

Comment on the interactions between instructor and students

Comment on the interactions between students

5. Other general comments:

Immediate Post-Observation Questions

General Questions:

Was this a typical class?

What was your impression of how it went?

What's your impression of how well you achieved your goals for the class?

Specific Questions (based on observation notes):

B.4 Reflection Log

Pick a single lecture/topic/unit that you will be teaching between now and the February meeting and answer the following questions:

1. Define your objectives / goals for that lecture/topic/unit.

2. What instructional design technique will you use? Why?

3. What assessment technique will you use to determine if your objectives / goals were met? Why that one?

Now deliver the lecture/topic/unit. As soon after delivery is complete, answer the following questions:

4. So how did it go? What went right? What could have been improved? How?

5. Did you meet your objectives / goals? How do you know?

6. If you were telling someone else how to deliver this lecture / topic / unit, what would you tell them?

Bring your answers in hardcopy to the February meeting.

APPENDIX C STUDY 2 MATERIALS

This section includes materials that were used in study 2.

C.1 Recruitment Text

We are starting the second year of our Disciplinary Commons for Computing Educators (DCCE) project at Georgia Tech to help high school and undergraduate computer science teachers improve their teaching practice and increase communication among faculty in the state. We are looking for teachers, at both levels, to participate in a yearlong project, sponsored by new funding from the National Science Foundation.

The idea is to gather Georgia high school teachers and undergraduate faculty together in a series of monthly meetings to discuss computer science education and to document and share knowledge about teaching and student learning in introductory Computer Science courses. From our work with "Georgia Computes!" (http://www.gacomputes.org), we know that many high school and undergraduate teachers are interested in what happens at the other level and are looking for the opportunity to improve their teaching in computer science. In DCCE, participants will have the opportunity to talk with one another and to work together to document, review and reflect on your own classroom teaching through the shared production of course portfolios. We are expecting results to include a peer-reviewed course portfolio from each teacher, enhanced understanding of how high school and undergraduate computing education can work together, and ultimately better teaching and improved student learning. More information about the Disciplinary Commons for Computing Educators (DCCE) project can be found at http://home.cc.gatech.edu/dcce. We will meet Saturdays every 4-6 weeks on the Georgia Tech campus, starting in October 24, 2009.

We will be accepting around 10 participants each year, with half from high school and half from undergraduate teaching. You are eligible to participate if you are teaching Advanced Placement CS (AP-CS) in the 2009-2010 academic year. We particularly encourage applications from teams of a high school and undergraduate teacher from the same geographic region.

Successful participation in DCCE is expected to offer professional development for participants, as well as community development for Georgia computer science teachers.

*** Benefits to Participation**

- Professional development: As consistently reported in research literature, teachers creating course portfolios state that the critical reflection involved in portfolio construction results in significant and lasting changes to the course and to their own subsequent teaching.

• Community development: Although a culture of peer review and discourse is common within research communities, it is rare among teachers as teaching most often happens in isolation, "behind closed doors". As we document our own work and review each other's, we overcome insularity and secrecy and are able to identify knowledge and best practices, which can be developed and shared as community resources.

• Documentation of practice: In a course portfolio, participants will have a persistent, peer-reviewed, documented deliverable that can be shared with others both inside of, and external to, their home institution.

*** Community Benefit**

By bringing high school and university level instructors together, each will have the opportunity to "peer into" the other's community. In last year's DCCE one of the most valued benefits was learning of the overall curriculum available within each environment. By sharing experiences, techniques, and approaches to teaching this often difficult course, a community of engaged and focused educators can emerge.

Please note: the DCCE does not:
* Aim to generate a courseware repository;
* nor is it a workshop for developing materials.

There will be no cost for participation: travel costs, hotel rooms for the night before a meeting as needed, lunches and breaks at meetings will be covered by the grant from the NSF CPATH program. You will also be paid a small stipend ($500) for participating.

If accepted, each participant is expected to commit to:

- Attending all the DCCE meetings (full-day and half day meetings, around 40 hours in total).
- Completing a course portfolio for your introductory computer science course.
- Reading a small number of papers that will help in carrying out the goals of the project.
- Undertaking a peer observation of another participant, as well as being observed by another participant in turn.
- Reading and critiquing portions of other participants' portfolios.

If you are interested in participating, please email Lijun Ni (lijun@cc.gatech.edu) with the following information:

- Contact information: your name, e-mail address, the name of your school, a mailing address, and phone number.
- Please provide a brief position statement (a couple of paragraphs). This should indicate who you are, where you're starting from, what courses you regularly teach (name plus one-sentence description for each), what classes you teach this year, what you find hard or challenging about teaching introductory computer science, and what you hope to get out of participating in this project.
- How long have you been a teacher? How long have you been teaching computing courses? How long have you been teaching AP-CS?

- Are you applying with a "partner" – another teacher, at a different level than yourself?
- Are there any periods which you know would cause problems for attending a monthly meeting? (e.g. are you going to be away, or at a conference?). Is there anything else about scheduling we should know about?
- Is there anything else you would like to add?

THE DEADLINE FOR APPLICATIONS IS SEPTEMBER 25, 2009. We anticipate making decisions and contacting participants by October 2, 2009.

Thank you for your consideration. Please feel free to pass this message along to your colleagues who might be interested.

C.2 Post-DCCE Identity Interview (A)

This interview will include most of the same questions in the CS Teacher Identity Interview Protocol (attached in B.3).

C.3 DCCE Experience Interview (B)

1. Can you tell me things you struggled in the past year, or are still struggling about your own theories of being a teacher who teaches CS courses? When and what you did you struggle/are struggling with? Why? How is your participation in DCCE related to the things you struggled? E.g., any experience in DCCE caused that struggle, helped relieve or strengthened that struggle?
2. What aspects or qualities (if any) of the DCCE did you find most/least valuable?
3. Tell me about what you learned through creating your course portfolio?
4. What, if any, did you learn through reviewing other DCCE participants' course portfolios?
5. What, if any, did you learn through observing other DCCE participants' classroom?
6. Describe the roles the two teacher leaders played in the meeting. In what ways, if any, these two leaders have influence on your thoughts about yourself and the way you teach CS courses?
7. What do you think about bringing teachers from both UG and HS together? In what ways, if any, could the discussions during the meetings inform you?
8. Please describe any important connections you made between other participants' insight, perspective, or experiences and your own insights.
9. What changes, if any, have you made in your classroom as a result of your participation in DCCE?
    a. Changes to your feelings about yourself and your teaching
    b. Changes to your theories about teaching CS
    c. Changes to content delivered.
    d. Changes to pedagogy.
    e. Why do you think you made these changes?

C.4 Community Leader Interview (C)

1. Tell me about teacher A's participation in DCCE
   Has that changed in the past year of DCCE program? In what ways?

2. How would you describe teacher A's confidence in this group? What would you say are his/her interests and goals in attending DCCE?

3. How is teacher A' participation similar or different from other teachers?

4. How does teacher A work in this group? What roles does he/she play in this group?

5. What kind of support/help did you provide to teacher A and why?

6. How would you describe teacher A's perceptions about himself/herself as a CS teacher?
   What would you say about her motivation, confidence, values of teaching CS?
   How have they changed over time?

7. Is there any particular perspective or experience expressed by teacher A that strike you, or surprise you, from their portfolios, review process, discussions, etc? Why?

C.5 Administrator Interview (D)

Below is the list of questions asked in the interview with Cindy's administrator (A1).

About Identity:

1. What do you think is the primary teaching responsibility for Cindy?(As primarily in math, CS, mainly math, or mainly CS?) Did that change over the past year?

2. What would you say about her long-term professional goals? (e.g., build a CS program, stay as a good math teacher, etc.) Have you noticed any change in her long-term goals?

School context:

3. Does your department value (math teachers') CS teaching? Is it valuable to grow the CS program for your department?
4. How does your department evaluate teachers? What are the usual criteria for keeping/opening a new course, e.g., a minimal number of students in a class, class performance and feedback?
5. It that common for teachers in our department to make additional efforts to recruit students?

Change:

6. Over the past year, did you recall that she asked for any additional resources/technical supports for her CS classes, e.g., buying new software, more computer time, more planning periods for her, reallocate her math classes to other teachers?
7. Did she tell you about her recruitment plan and results for her AP CS course? What do you think motivated her efforts to grow the class size? Any support did the department offered for this recruitment event?
8. As the new academic year starts, do you notice any changes she has made or is planning to make in her teaching of CS?

About PD and DCCE:

9. Does the department encourage teachers' professional development? In what ways? (e.g., offering monthly PD afternoon, acknowledge PD efforts in teacher evaluation, etc.)
10. Do (would) you support a teacher going to local community of teachers?
11. Have you heard her talking about the DCCE (GaTech CS teacher workshop)? What did she say about that?

Other: Anything particular you want to share with us about Mrs. Furman?

APPENDIX D DCCE PROGRAMMATIC EVALUATION MATERIALS

This appendix includes the materials used to evaluate the DCCE program.

D.1 DCCE Meeting Feedback Form (The Fourth Meeting: January 16, 2010)

Please rate the agenda items from today's meeting on a scale from 1 to 4 based on how informative, useful, and engaging you found it to be.

DISCUSSION: REVIEW COMMENTS FOR COURSE CONTENT AND OVERALL PORTFOLIOS		
Not Informative	□ □ □ □	Informative
Not Useful	□ □ □ □	Useful
Not Engaged	□ □ □ □	Engaged
DISCUSSION: IRB ISSUES		
Not Informative	□ □ □ □	Informative
Not Useful	□ □ □ □	Useful
Not Engaged	□ □ □ □	Engaged
DISCUSSION: READINGS AND INSTRUCTIONAL DESIGN TECHNIQUES		
Not Informative	□ □ □ □	Informative
Not Useful	□ □ □ □	Useful
Not Engaged	□ □ □ □	Engaged
SMALL GROUP TRIADS: INSTRUCTIONAL DESIGN FOR A SPECIFIC UNIT		
Not Informative	□ □ □ □	Informative
Not Useful	□ □ □ □	Useful
Not Engaged	□ □ □ □	Engaged
WORKING LUNCH: RESULTS FROM TRIADS		
Not Informative	□ □ □ □	Informative
Not Useful	□ □ □ □	Useful
Not Engaged	□ □ □ □	Engaged
INTRODUCTION TO PEER OBSERVATION		
Not Informative	□ □ □ □	Informative
Not Useful	□ □ □ □	Useful
Not Engaged	□ □ □ □	Engaged

Based on today's meeting, I can…	**Rate from 1 (not at all) to 4**

	(to a great extent)
1. Describe comments from my reviewers about my portfolio.	□ □ □ □
2. Explain the explicit instructional design decisions concerning my course.	□ □ □ □
3. Identify teaching methods used by other participants in their courses.	□ □ □ □

ONE QUESTION I HAVE REMAINING IS…

MY NEXT STEP IS TO…

I WOULD IMPROVE FUTURE MEETINGS BY…

D.2 Pre- DCCE Workshop Survey

Name: _____

1. Which of the following best describes the institution where you teach?

- O High Schools
- O Community college
- O Technical college
- O Four year college/university, not research intensive
- O Research intensive university
- O Other: _____

2. Which of the following best describes your current position within your institution?

- O High school teacher
- O Tenured faculty
- O Tenure-track faculty
- O Non-tenure-track faculty
- O Other:_____

3A. If you are an undergraduate instructor, which of the following best describe your introductory programming course(s)? Select all that apply.

- ☐ A one-term class specifically for non-majors
- ☐ A sequence of courses specifically for non-majors
- ☐ A one-term class designed only for majors
- ☐ A sequence of courses specifically for majors
- ☐ A one-term class taken by both majors and non-majors
- ☐ A sequence of courses taken by both majors and non-majors
- ☐ Other: _____

3B. If you are a high school teacher at a high school offering AP CS, which of the following best describe your AP course? Select all that apply.

- ☐ AP is the first programming class at my school
- ☐ Most students take another programming course before AP
- ☐ Students are required to take another programming course before AP
- ☐ The AP class is open to anyone
- ☐ The class is only open to qualified students (either by math score, honors, etc.)
- ☐ The class is restricted by grade level
- ☐ My school does not offer AP CS
- ☐ Other restrictions: _____

4. In which (degree) program, if any, is the intro CS course(s) required?

5. In a typical year, how many courses do you teach?	**6.** In a typical year, how many *Computer Science* courses do you teach?
☐ None ☐ One ☐ Two or Three ☐ Four or Five ☐ More than Five	☐ None ☐ One ☐ Two or Three ☐ Four or Five ☐ More than Five

7. How many years have you been teaching at the college/secondary level?	**8.** How many years have you been teaching *Computer Science* at the college /secondary level?
_____	_____

9. Would you say there are any institutional restrictions on the types of changes you can make to the course that you will be investigating during DCCE?	**9a.** If "yes" or "kind of," please describe.
☐ Yes ☐ No ☐ Kind of	

SECTION 2: COMMUNITY OF PRACTICE

10. How often do you discuss teaching with the following individuals?	Never	Once a year or less	Approx. once per term	A few times during each term	Many times during each term
A. Other instructors/teachers in your department	☐	☐	☐	☐	☐
B. Other instructors/teachers at your institution outside your department	☐	☐	☐	☐	☐
C. Your department chair	☐	☐	☐	☐	☐
D. Staff at your institution who specialize in teacher/faculty development (e.g., at a center for teaching and learning)	☐	☐	☐	☐	☐

E. Instructors/teachers who teach similar courses as you at other institutions/schools	☐	☐	☐	☐	☐

11. Please indicate how much you agree or disagree with the following statements.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A. I feel connected to a network of colleagues in my geographic region who are interested in issues of teaching and learning	☐	☐	☐	☐	☐
B. I feel connected to a network of colleagues outside my geographic region who are interested in issues of teaching and learning	☐	☐	☐	☐	☐
C. I feel that I have adequate opportunities to discuss issues of teaching and learning in general with my colleagues	☐	☐	☐	☐	☐
D. I feel that I have adequate opportunities to discuss issues of teaching and learning in computing with my colleagues	☐	☐	☐	☐	☐
F. Instructors/teachers who do not teach similar courses at other institution/schools	☐	☐	☐	☐	☐
G. Graduate students, post-doctoral researchers, or student teachers you work with	☐	☐	☐	☐	☐

12. How many times in a typical academic year did you observe other instructors'/teachers' teaching?	**12a**. For what purpose(s) did you observe other instructors' teaching?

O None [go to 13] O Once or twice O Three to five times O More than five times	

13. How many times in a typical academic year is your teaching observed?	**13a.** For what purpose(s) has your teaching been observed?
O None [go to 14] O Once or twice O Three to five times O More than five times	

Section 3: Reflections on Teaching Practices

14. How often do you…	Never	Once a year or less	Approx. once per term	A few times during each term	Many times during each term
A. Reflect on your teaching practices	□	□	□	□	□
B. Document your reflections on your teaching (e.g., journal, teaching portfolio)	□	□	□	□	□
C. Read scholarly work on teaching in computing	□	□	□	□	□
D. Attend workshops or conferences with a focus on computing education	□	□	□	□	□
E. Consult with a faculty development office or staff member on campus	□	□	□	□	□
F. Try a new teaching practice based on reflection	□	□	□	□	□
G. Try a new teaching	□	□	□	□	□

practice based on student feedback					
H. Try a new teaching practice based on scholarly work/ research	□	□	□	□	□
I. Conduct an informal study to assess the impact of changes to your teaching	□	□	□	□	□
J. Employ a method of assessment beyond standard course evaluations	□	□	□	□	□

15. Have you published and/or presented scholarly work related to your teaching of computing at a conference?	**16.** Approximately what percentage of your professional work is spent doing scholarly work (e.g., conducting studies, writing papers, giving professional presentations) on computing education?
O Yes O No O In preparation	O None O Less than 5% O 6 – 10% O 11 – 20% O 21 – 30% O 31 – 40% O 41 – 50% O More than 50%

SECTION 4: PORTFOLIOS

The next set of questions focuses on the distinction between a *course* portfolio and a *teaching* portfolio and your experience with each.

17. Please indicate how much you agree or disagree with the following statements.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A. I understand the difference between a teaching portfolio and a course portfolio.	□	□	□	□	□
B. I can clearly articulate my teaching philosophy.	□	□	□	□	□
C. I can provide concrete examples to illustrate my teaching philosophy.	□	□	□	□	□

18. Have you ever constructed a ***teaching*** portfolio?

- O Yes [go to 18A]
- O No [go to 18F]
- O Partial [go to 18A]

18A. For what purpose(s) did you construct a teaching portfolio, or part of one? Please select all that apply.

- ☐ Job application
- ☐ Requirement for promotion/tenure
- ☐ Requirement for a course
- ☐ Personal enrichment
- ☐ As part of a workshop, seminar, or conference
- ☐ Other: _____

18B. Did you share your teaching portfolio (or part of it) with anyone else?

- O Yes [go to 18C]
- O No [go to 18D]

18C. With whom did you share your teaching portfolio (or part of it)? Please select all that apply.

- ☐ Other instructors in your department
- ☐ Other instructors at your institution outside of your department
- ☐ Your department chair
- ☐ Tenure & promotion committee
- ☐ Staff who specialize in teacher/faculty development (e.g., at a center for teaching and learning) at your institution
- ☐ Instructors at other institutions in the discipline
- ☐ Instructors at other institutions not in the discipline
- ☐ Graduate students or researchers you work with
- ☐ Posted it online and publicly accessible
- ☐ Other: _____

18D. What do you believe is the primary purpose of a teaching portfolio?

18E. In general, what would you say are the benefits of sharing your teaching portfolio?

18F. Please describe any specific reservations about sharing your teaching portfolio?

19. Have you ever constructed a ***course*** portfolio?

- O Yes [go to 19A]
- O No [go to 19F]
- O Partial [go to 19A]

19A. For what purpose(s) did you construct a course portfolio, or part of one? Please select all that apply.

- ☐ Job application
- ☐ Requirement for promotion/tenure
- ☐ Requirement for a course
- ☐ Personal enrichment
- ☐ As part of a workshop, seminar, or conference
- ☐ Other: _____

19B. Did you share your course portfolio (or part of it) with anyone else?

- O Yes [go to 19C]
- O No [go to 19D]

19C. With whom did you share your course portfolio (or part of it)? Please select all that apply.

- ☐ Other departmental instructors at your institution
- ☐ Other instructors at your institution outside of your department
- ☐ Your department chair
- ☐ Staff who specialize in teacher/faculty development (e.g., at a center for teaching and learning) at your institution
- ☐ Tenure & promotion committee
- ☐ Instructors at other institutions in the discipline
- ☐ Instructors at other institutions not in the discipline
- ☐ Graduate students or researchers you work with
- ☐ Posted it online and publicly accessible
- ☐ Other: _____

19D. What do you believe is the primary purpose of a course portfolio?

19E. In general, what would you say are the benefits of sharing your course portfolio?

19F. Please describe any specific reservations about sharing your course portfolio?

SECTION 5: DISCIPLINARY COMMONS FOR COMPUTING EDUCATORS

21. How did you hear about the DCCE project?

22. WHAT ASPECTS OR QUALITIES (IF ANY) OF THE DCCE DO YOU THINK WILL BE THE MOST VALUABLE TO YOU?

23. WHAT ASPECTS OR QUALITIES (IF ANY) OF THE DCCE DO YOU THINK WILL BE LESS VALUABLE TO YOU?

24. ADDITIONAL COMMENTS?

D.3 Post-DCCE Workshop Survey

Name: _____

SECTION 1: YOUR PARTICIPATION AND YOUR PORTFOLIO

1. Approximately how many Disciplinary Commons sessions did you attend?	**2.** Approximately what proportion of monthly "homework" assignments did you complete?
O Never missed any O Missed one O Missed two O Missed three to five O Missed more than five	O Never missed any O Missed one O Missed two O Missed three to five O Missed more than five

3. During the year in which you participated in the Disciplinary Commons, how often did you write reflective comments related to your course or your teaching that are private (i.e. only for yourself)?	**4.** At this point, what would you say is the status of your course portfolio?
O Approximately once a week or more O Every few weeks O Approximately once per month O Several times but not systematically O Once or twice O Never	O It is complete O All of the components are complete, but the portfolio needs some revisions and/or refinement O Most of the components are complete, but not all O Only a few of the components are complete O Other: _____

4. How, if at all, do you think you will use your course portfolio in the future?

5. Other than putting your portfolio online, do you plan to share your course portfolio (or part of it) with anyone else outside of your Disciplinary Commons cohort?
O Yes [go to 5A] O No [go to 6]

5A. If "yes", with whom did you share your teaching portfolio (or part of it)? Please select all that apply.

- ☐ Other instructors in your department
- ☐ Other instructors at your institution outside of your department
- ☐ Your department chair
- ☐ Instructors at other institutions in the discipline
- ☐ Instructors at other institutions not in the discipline
- ☐ Graduate students or post-doctoral researchers you work with
- ☐ At a regional conference
- ☐ At a national conference
- ☐ In a journal publication
- ☐ Other: _____

6. At this point, what do you believe is the primary purpose of a course portfolio?

7. In general, what would you say are the benefits, if any, of generating a course portfolio?

8. Please describe any reservations you have about sharing your course portfolio publicly?

9. Please indicate how much you agree or disagree with the following statements.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
H. At this point, I understand the difference between a teaching portfolio and a course portfolio	☐	☐	☐	☐	☐
I. I can clearly articulate my teaching philosophy	☐	☐	☐	☐	☐
J. I can provide concrete examples to illustrate my teaching philosophy	☐	☐	☐	☐	☐

10. During your Disciplinary Commons experience, did you…?	No, not at all	Not really, or only sort of	Yes, Somewh at	Yes definitely
A. . . . come to better understand your teaching philosophy?	☐	☐	☐	☐
B. …see new connections between your teaching philosophy and teaching practices?	☐	☐	☐	☐
C. …connect concepts from one monthly Commons session to concepts from previous monthly Commons sessions?	☐	☐	☐	☐
D. …gain new ideas for teaching practices from other Disciplinary Commons participants?	☐	☐	☐	☐
E. . . .adopt practices from other Disciplinary Commons participants?	☐	☐	☐	☐
F. . . . change your teaching practices during the year?	☐	☐	☐	☐
G. . . . make plans to change your teaching practices the next time you teach this course?	☐	☐	☐	☐
H. . . . make changes to software engineering courses beyond the one addressed in your portfolio?	☐	☐	☐	☐
I. . . . develop ideas for changing software engineering courses beyond the one addressed in your portfolio?	☐	☐	☐	☐

SECTION 2: YOUR DISCIPLINARY COMMONS EXPERIENCE

11. Please indicate how often you will engage in the following activities in the coming academic year.	Never	Once during the year	Approx once per term	Several times during each term	Many times during each term
A. Reflect on my teaching practices	☐	☐	☐	☐	☐
B. Document my reflections on my teaching (e.g., journal, teaching portfolio)	☐	☐	☐	☐	☐
C. Read scholarly work on teaching in the discipline	☐	☐	☐	☐	☐
D. Attend workshops or conferences with a focus on computing education	☐	☐	☐	☐	☐
E. Consult with a faculty development office or staff	☐	☐	☐	☐	☐

member on campus					
F. Try a new teaching practice based on reflection	☐	☐	☐	☐	☐
G. Try a new teaching practice based on student feedback	☐	☐	☐	☐	☐
H. Try a new teaching practice based on scholarly work	☐	☐	☐	☐	☐
I. Conduct an informal study to assess the impact of changes to my teaching practices	☐	☐	☐	☐	☐
J. Employ a method of assessment beyond standard course evaluations	☐	☐	☐	☐	☐

12. Please indicate how much you agree or disagree with the following statements about Disciplinary Commons.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A. …I have a clearer understanding of the learning objectives for the course that I investigated.	☐	☐	☐	☐	☐
B. …I have a better understanding of why I teach this course the way that I do.	☐	☐	☐	☐	☐
C. … the course that I investigated has better alignment between the learning objectives, the teaching and learning activities, and the learning assessments.	☐	☐	☐	☐	☐
D. …. I now have a better understanding of what "good teaching" is.	☐	☐	☐	☐	☐
E. … I am better able to provide feedback to colleagues on their teaching and course materials.	☐	☐	☐	☐	☐

13. What, if anything, would you say was the most important insight you gained during your Disciplinary Commons experience?

14. Following up on Question 13, how did this insight come about? What led you to this new knowledge?

SECTION 3: COMMUNITY OF PRACTICE

15. Please rate the value of different aspects of interactions with your Disciplinary Commons peers (if you don't have experience with that particular type of interaction, select "N/A").	N/A	Not at all valuable	Not Valuable	Valuable	Extremely Valuable
A. Peer review of course portfolio content	☐	☐	☐	☐	☐
B. Plenary discussions	☐	☐	☐	☐	☐
C. Structured activities/exercises	☐	☐	☐	☐	☐
D. Informal interactions in small groups	☐	☐	☐	☐	☐
E. Peer observation of teaching	☐	☐	☐	☐	☐
F. Email exchanges	☐	☐	☐	☐	☐

16. Please indicate how much you agree or disagree with the following statements about your interactions with other Disciplinary Commons participants.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A. In general, participants were willing to share their own perspectives even if they differed from each other region	☐	☐	☐	☐	☐
B. During the year, I learned about other participants' perspectives.	☐	☐	☐	☐	☐
C. I felt comfortable expressing my perspective in Disciplinary Commons sessions.	☐	☐	☐	☐	☐
D. At times, I held back my own opinion to avoid conflict.	☐	☐	☐	☐	☐
E. I believe the feedback I received in peer review of portfolio content was honest	☐	☐	☐	☐	☐
F. Occasionally, the feedback I provided on portfolio content was not as incisive as it could have been because I did not want to be	☐	☐	☐	☐	☐

too harsh.					
G. I plan on staying in touch with my Disciplinary Commons cohort	☐	☐	☐	☐	☐

17. Please describe any important connections you made between other participants' insight, perspective, or experiences and your own teaching practices

18. For what purpose, if any, might you contact members of your Disciplinary Commons cohort in the future?

19. Please indicate how much you agree with the following statements about your Disciplinary Commons experience.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A. As a whole, I enjoyed my Disciplinary Commons experience.	☐	☐	☐	☐	☐
B. I think my decision to take part in the Disciplinary Commons was a good one.	☐	☐	☐	☐	☐
C. Being a part of the Disciplinary Commons was a positive addition to my CV.	☐	☐	☐	☐	☐
D. The reflections on my teaching that I did as a Disciplinary Commons participant was well-integrated into my career goals.	☐	☐	☐	☐	☐
E. I believe that my participation in the Disciplinary Commons advanced my career.	☐	☐	☐	☐	☐
F. At this point, I consider participation in the Disciplinary Commons a good use of my time.	☐	☐	☐	☐	☐
G. During the Disciplinary Commons, I learned more about how to assess student learning than I had known before.	☐	☐	☐	☐	☐

20. Please rate the following aspects of Disciplinary Commons?	Poor	Average	Good	Very Good	Excellent
A. Level of organization:	☐	☐	☐	☐	☐
B. Coherence across sessions:	☐	☐	☐	☐	☐
C. Logical sequence of sessions	☐	☐	☐	☐	☐
D. Relevance of assignments to sessions	☐	☐	☐	☐	☐
E. Appropriateness of assignments	☐	☐	☐	☐	☐
F. Relevance of readings to sessions	☐	☐	☐	☐	☐
G. Appropriateness of readings	☐	☐	☐	☐	☐
H. Overall structure of the program	☐	☐	☐	☐	☐
I. Online materials	☐	☐	☐	☐	☐
J. The facilitator's contribution to the Disciplinary Commons	☐	☐	☐	☐	☐
K. Use of session time	☐	☐	☐	☐	☐
L. Facilitator's effectiveness in guiding discussions during Disciplinary Commons sessions.	☐	☐	☐	☐	☐
M. Disciplinary Commons overall.	☐	☐	☐	☐	☐

SECTION 4: EVALUATION

21. What aspects or qualities (if any) of the Disciplinary Commons did you find most valuable?

22. What aspects or qualities (if any) of the Disciplinary Commons did you find least valuable?

23. How, if at all, could the Disciplinary Commons program be improved?

24. Please provide any comments and/or constructive feedback specifically for the Disciplinary Commons facilitator.

25. Additional comments

D.4 DCCE Social Network Analysis Form

Your Name:

Your School/University:

PARTNERSHIPS				
WE ARE INTERESTED IN THE EXTENT TO WHICH YOU INTERACT WITH THE FOLLOWING INDIVIDUALS. PLEASE INDICATE THE EXTEND OF YOUR RELATIONSHIP.	1. I HAVE NEVER MET THIS PERSON.	2. I KNOW THIS PERSON BUT WE HAVE NEVER COLLABORATED.	3. WE HAVE SHARED MATERIALS AND IDEAS, BUT HAVE NEVER FORMALLY WORKED ON A PROJECT TOGETHER.	4. WE HAVE FORMALLY WORKED TOGETHER ON AT LEAST ONE PROJECT.
PARTICIPANT AF19F	1	2	3	4
PARTICIPANT B	1	2	3	4
PARTICIPANT C	1	2	3	4
PARTICIPANT D	1	2	3	4
PARTICIPANT E	1	2	3	4
PARTICIPANT F	1	2	3	4
PARTICIPANT G	1	2	3	4
PARTICIPANT H	1	2	3	4
PARTICIPANT I (TEACHER LEADER)	1	2	3	4
PARTICIPANT J (TEACHER LEADER)	1	2	3	4

If you have never met any of these people, please skip the next page and proceed to item 10.

---

[19] Actual participant names are removed in this document.

INDIVIDUAL COLLABORATIONS AND PARTNERSHIPS			
	5. I have received advice, materials, or other help from this person.	**6. This person has requested advice, materials, or other help from me.**	**7. I have formally partnered with this person on at least one project.**
1. **Participant A**	Y Yes	Y Yes	Y Yes
2. **Participant B**	Y Yes	Y Yes	Y Yes
3. **Participant C**	Y Yes	Y Yes	Y Yes
4. **Participant D**	Y Yes	Y Yes	Y Yes
5. **Participant E**	Y Yes	Y Yes	Y Yes
6. **Participant F**	Y Yes	Y Yes	Y Yes
7. **Participant G**	Y Yes	Y Yes	Y Yes
8. **Participant H**	Y Yes	Y Yes	Y Yes
9. **Participant I (Teacher Leader)**	Y Yes	Y Yes	Y Yes
10. **Participant J (Teacher Leader)**	Y Yes	Y Yes	Y Yes

8. BRIEFLY DESCRIBE YOUR PARTNERSHIPS WITH ANY INDIVIDUAL YOU IDENTIFIED ABOVE.	**9. BRIEFLY DESCRIBE ANY ADVICE, MATERIALS OR OTHER HELP YOU RECEIVE FROM ANY INDIVIDUAL ABOVE.**

ORGANIZATIONAL COLLABORATIONS AND PARTNERSHIPS				
	10. I have received advice, materials, or other help from faculty at this organization.	**11. This organization has requested advice, materials, or other help from me.**	**12. I have worked on at least one project with this organizatio n.**	**13. At least one colleague in my school/department that I know has worked on a project with this organization.**
1. **Participant A**	Y Yes N No	Y Yes N No	Y Yes N No	Y Yes n No O Not Sure
2. **Participant B**				
3. **Participant C**	Y Yes N No	Y Yes	Y Yes	Y Yes n No

		N No	N No	O Not Sure
PARTICIPANT D	Y Yes N No	Y Yes N No	Y Yes N No	Y Yes n No O Not Sure
PARTICIPANT E	Y Yes N No	Y Yes N No	Y Yes N No	Y Yes n No O Not Sure
PARTICIPANT F	Y Yes N No	Y Yes N No	Y Yes N No	Y Yes n No O Not Sure
PARTICIPANT G	Y Yes N No	Y Yes N No	Y Yes N No	Y Yes n No O Not Sure
PARTICIPANT H	Y Yes N No	Y Yes N No	Y Yes N No	Y Yes n No O Not Sure
PARTICIPANT (TEACHER LEADER)	Y Yes N No	Y Yes N No	Y Yes N No	Y Yes n No O Not Sure
PARTICIPANT J (TEACHER LEADER)	Y Yes N No	Y Yes N No	Y Yes N No	Y Yes n No O Not Sure

14. BRIEFLY DESCRIBE ANY WORK YOU HAVE DONE WITH INDIVIDUALS AT AN ORGANIZATION YOU IDENTIFIED ABOVE.	**15. BRIEFLY DESCRIBE ANY ADVICE, MATERIALS, OR OTHER HELP YOU RECEIVED FROM ORGANIZATION IDENTIFIED ABOVE.**

REFERENCES

Alsup, J. (2006). Teacher Identity Discourses: Negotiating Personal and Professional Spaces: Routledge, USA.

Andrew, M. D. (1997). What matters most for teacher educators? Journal of Teacher Education 48(3), 167-176.

Antonek, J. L., McCormick, D. E., & Donato, R. (1997). The Student Teacher Portfolio as Autobiography: Developing a Professional Identity. The Modern language journal., 81(1), 15.

Beauchamp, C., & Thomas, L. (2009). Understanding teacher identity: an overview of issues in the literature and implications for teacher education. Cambridge Journal of Education, 39(2), 175-189.

Beijaard, D., Meijer, P. C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. Teaching and Teacher Education, 20(2), 107-128.

Beijaard, D., Verloop, N., & Vermunt, J. D. (2000). Teachers' perceptions of professional Identity: An exploratory study from a personal knowledge perspective Teaching and. Teacher Education, 16, 749-764.

Borko, H. (2004). Professional development and teacher learning: mapping the terrain. Educational Researcher, 33(8), 3-15.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). How people learn: Brain, mind, experience, and school (Expanded ed.). Washington, D.C.: National Academy Press.

Cardelle-Elawar, M., Irwin, L., Lizarraga, S. d. A., & Lusia, M. (2007). A cross cultural analysis of motivational factors that influence teacher identity. Electronic Journal of Research in Educational Psychology 5(3), 565-592.

Cardelle-Elawar, M., Irwin, L., & Sanz de Acedo Lizarraga, M. L. (2007). A Cross Cultural Analysis of Motivational Factors that Influence Teacher Identity. Electronic Journal of Research in Educational Psychology 5(3), 565-592.

Carr, W., & Kemmis, S. (1986). Becoming critical: education, knowledge, and action research: Routledge.

Cerbin, W. (2001). The Course Portfolio. APS Observer, 14(4).

Chan, W.-Y., Lau, S., Nie, Y., Lim, S., & Hogan, D. (2008). Organizational and personal predictors of teacher commitment: The mediating role of teacher efficacy and

identification with school. American Educational Research Journal, 45(3), 597-630.

Clandinin, D. J., & Connelly, F. M. (2000). Narrative Inquiry: Experience and Story in Qualitative Research. San Francisco: Jossey-Bass Publishers.

Cuny, J. (2010). Finding 10,000 teachers: Transforming high school computer science. The CSTA Voice, 5(6), 1-2.

Curran, B., & Goldrick, L. (2002). Mentoring and Supporting New Teachers. National Governors Association for Best Practices.

Darling-Hammond, L., Berry, B., & Thoreson, A. (2001). Does teacher certification matter? Evaluating the evidence. Educational Evaluation and Policy Analysis, 23(1), 57-77.

Day, C., Kington, A., Stobart, G., & Sammons, P. (2006). The personal and professional selves of teachers: Stable and unstable identities. British Educational Research Journal, 32(4), 601-616.

Denning, P. (2005). Is computer science science? Communications of the ACM, 48(4), 27-31.

Denning, P. J., & Rosenbloom, P. S. (2009). Computing: The fourth great domain of science. Communications of the ACM 52(9), 27-29.

Diamond, C. T. (1993). Writing to reclaim self: The use of narrative in teacher education. Teaching and Teacher Education, 9(5-6), 511-517.

Elliott, J. (2001). Action Research for Educational Change Open University Press

Ericson, B., Armoni, M., Gal-Ezer, J., Seehorn, D., Stephenson, C., & Trees, F. (2008). Ensuring exemplary teaching in an essential discipline: addressing the crisis in computer science teacher certification: Final report of the CSTA teacher certification task force. from http://www.csta.acm.org/Communications/sub/DocsPresentationFiles/CertificationFinal.pdf

Erikson, E. H. (1956). The problem of ego identity. Journal of the American Psychoanalytic Association, 4, 56-121.

Erikson, E. H. (1968). Identity: Youth and Crisis. New York: W. W. Norton & Company.

Fincher, S., & Tenenberg, J. (2007). Warren's question. Paper presented at the Third International Computing Education Research Workshop (ICER), Atlanta, GA, USA.

Gee, J. P. (2001). Identity as an analytic lens for research in education. Review of Research in Education, 25, 99-125.

Goode, J. (2010). The digital identity divide. How technology knowledge impacts college students. New Media & Society., 12(3), 497-513.

Grier, J. M., & Johnston, C. C. (2009). An inquiry into the development of teacher identities in STEM career changers. Journal of Science Teacher Education, 20(1), 57-75.

Hong, J. Y. (2010). Pre-service and beginning teachers' professional identity and its relation to dropping out of the profession. Teaching and Teacher Education, 26(8), 1530-1543.

Hutchins, P. (Ed.). (1998). The Course Portfolio: How Faculty Can Examine Their Teaching to Advance Practice and Improve Student Learning: American Association for Higher Education.

Ingersoll, R. M. (2001). Teacher turnover and teacher shortages: an organizational analysis. American Educational Research Journal, 38(3), 499-534.

Ingersoll, R. M. (2002). The teacher shortage: A case of wrong diagnosis and wrong prescription. NASSP Bulletin, 86(631), 16-31.

Khoury, G. (2007). Computer Science State Certification Requirements: CSTA Certification Committee Report. from http://www.csta.acm.org/ComputerScienceTeacherCertification/sub/TeacherCertRept07New.pdf.

Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. New York, NY: Cambridge University Press.

Luehmann, A. L. (2007). Identity development as a lens to science teacher preparation. Science Education, 91(5), 822-839.

Lundeberg, M., Bergland, M., Klyczek, K., & Hoffman, D. (2003). Using action research to develop preservice teachers' beliefs, knowledge and confidence about technology. Journal of Interactive Online Learning. , from http://ncolr.uidaho.com/jiol/archives/2003/spring/toc.asp

Marcia, J. E. (1966). Development and validation of ego identity status. Journal of Personality and Social Psychology 3, 551-558.

Marcia, J. E. (Ed.). (1980). Identity in adolescence. New York: Wiley.

Margolis, J., Estrella, R., Goode, J., Holme, J. J., & Nao, K. (2008). Stuck in the Shallow End: Education, Race, and Computing: MIT Press (MA).

Martin, D. B. (2000). Mathematics Success and Failure Among African-American Youth: The Roles of Sociohistorical Context, Community Forces, School Influence, and Individual Agency. Routledge, USA.

Mead, G. H. (1934). Mind, Self, and Society. Chicago: University of Chicago Press.

Misa, T. J. (2010). Gender Codes: Why Women Are Leaving Computing. Wiley/IEEE Computer Society Press.

NCTAF. (2002). Unraveling the "teacher shortage" problem: Teacher retention is the key. Washington DC: National Commission on Teaching and America's Future (NCTAF).

NCTAF. (2003). No Dream Denied: A Pledge to America's Children. Washington DC: National Commission on Teaching and America's Future (NCTAF).

Ni, L. (2009). What makes CS teachers change? Factors influencing CS teachers' adoption of curriculum innovations Proceedings of the 40th ACM technical symposium on Computer Science Education (pp. 544-548). Chattanooga, TN, USA.

Ni, L., Guzdial, M., Tew, A. E., & McKlin, T. (2011). A regional professional development program for computing teachers: the Disciplinary Commons for Computing Educators. Paper presented at the the Annual Meeting of the American Educational Research, New Orleans, Louisiana,USA.

Ni, L., Guzdial, M., Tew, A. E., Morrison, B., & Galanos, R. (2011). Building a community to support HS CS teachers: the Disciplinary Commons for Computing Educators in Proceedings of the 42th ACM Technical Symposium on Computer Science Education Dallas, Texas, USA: 553-558.

Ni, L., Mcklin, T., & Guzdial, M. (2010). How do computing faculty adopt curriculum innovations? The story from instructors in the Proceedings of the 41th ACM technical symposium on Computer Science Education (pp. 544-548). Milwaukee, Wisconsin, USA.

Nias, J. (1987). Teaching and the self. Cambridge Journal of Education, 17(3), 178 - 185.

Ottensen, E. (2007). Teachers "in the making": Building accounts of teaching. Teaching and. Teacher Education, 23(5), 612-623.

Pennington, M. C. (2002). Teacher identity in TESOL. Paper presented at the Quality in Teacher Education Seminar.

Putnam, R., & Borko, H. (1996). Learning to teach. In D. Berliner & R. Calfee (Eds.), Handbook of Educational Psychology (pp. 673-708). New York: Macmillian.

Rodgers, C. R., & Scott, K. H. (Eds.). (2008). The development of the personal self and professional identity in learning to teach. London: Routledge & Association of Teacher Educators.

Sachs, J. (2005). Teacher education and the development of professional identity: Learning to be a teacher. In P. Denicolo & M. Kompf (Eds.), Connecting policy and practice: Challenges for teaching and learning in schools and universities (pp. 5-21). Oxford: Routledge.

Scherer, M. (Ed.). (1999). A better beginning: Supporting and mentoring new teachers: The Association for Supervision and Curriculum Development.

Seidman, I. (2005). Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences: Teachers College Press.

Seldin, P. (1993). Successful Use of Teaching Portfolios. Bolton, MA: Anker Publishing.

Sfard, A., & Prusak, A. (2005). Telling identities: In search of an analytic tool for investigating learning as a culturally shaped activity. Educational Researcher, 34(4), 14-22.

Shackelford, R. (2005). Why can't smart people figure out what to do about Computing Education? Paper presented at the CS and IT Symposium.

Tenenberg, J., & Fincher, S. (2007). Opening the door of the computer science classroom: The Disciplinary Commons. Paper presented at the 38th SIGCSE Technical Symposium on Computer Science Education.

Tickle, L. (1999). Professional Qualities and Teacher Induction. Journal of In-Service Education, 27(1), 51-64.

Tucker, A., McCowan, D., Deek, F., Stephenson, C., Jones, J., & Verno, A. (2006). A Model Curriculum for K-12 Computer Science: Report of the ACM K-12 Task Force Computer Science Curriculum Committee (2nd ed.). New York, NY: Association for Computing Machinery.

Volkmann, M. J., & Anderson, M. A. (1998). Creating professional identity: Dilemmas and metaphors of a first-year chemistry teacher. Science Education, 82(3), 293-310.

Wenger, E. (1998). Communities of Practice. New York, NY: Cambridge University Press.

Yin, R. K. (2008). Case Study Research: Design and Methods (Applied Social Research Methods): Sage Publications, Inc.

Zeichner, K. (1997). Action research as professional development in one urban school district. Paper presented at the Annual Meeting of AERA.

Zeichner, K., & Klehr, M. (1999). Teacher research as professional development for P-12 educators. National Partnership for Excellence and Accountability in Teaching, Washington, DC.

Zweben, S. (2011). Computing Research Association Taulbee Survey Report 2009-2010: http://www.cra.org/uploads/documents/resources/taulbee/CRA_Taulbee_2009-2010_Results.pdf.